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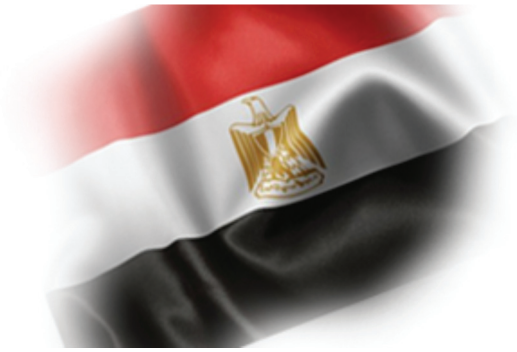

Over the past decade, clinical guidelines have increasingly become a familiar part of clinical practice. Every day, clinical decisions at the bedside, rules of operation at hospitals and clinics, and health spending by governments and insurers are being influenced by guidelines. As defined by the Institute of Medicine, clinical guidelines are "systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances."

The principal benefit of guidelines is to improve the quality of care received by patients.

the greatest benefit that could be achieved by guidelines is to improve health outcomes. Guidelines that promote interventions of proved benefit and discourage ineffective ones have the potential to reduce morbidity and mortality and improve quality of life,. Guidelines can also improve the consistency of care; making it more likely that patients will be cared for in the same manner regardless of where or by whom they are treated.

Introducing the Egyptian Guidelines "Nephrology Initiatives of Care and Excellency

A Message to the working Group and Contributors

It is with great pride to thank all the working Group and contributors and professors of all universities in Egypt who shared their thoughts, worked hard and in a professional way to complete this guidelines and this wonderful work which will improve the level of care and treatment for the kidney patients in Egypt and work with these instructions will surely have a positive impact in Quality of Care to Hemodialysis Patients in Egypt.

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Guideline on Hemodialysis Strategies

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Scope:

This Egyptian Clinical Practice Guideline document is based upon the best information available and it is designed to provide information and assist decision making and health care provider to optimize patient management to the excellency of hemodialysis therapy.

International Standards have been established to efficiently care for large numbers of patients on HD with a Balance of resources and The Best Health care outcomes.

(Cost Effective Program).

So, guidelines have been developed to assure patients, caregivers, and financial providers that reversal of the uremic state is the best that can be offered, and complications are minimized.

Major outcomes in Egyptian Hemodialysis Patients:

1. All-cause mortality.
2. Cardiovascular mortality.

3. Hospitalizations.
4. Hemodialysis Adequacy.
5. Quality of life and Socioeconomic Burdens.
6. Blood pressure control and Number of antihypertensive medications used.
7. Interdialytic weight gain (IDWG) and Ultrafiltration Rate applied.
8. Vascular Access Types.
9. Harms or complications related to vascular access or the process of dialysis.

Developing a SOP (Standard Operating Procedures SOPs)

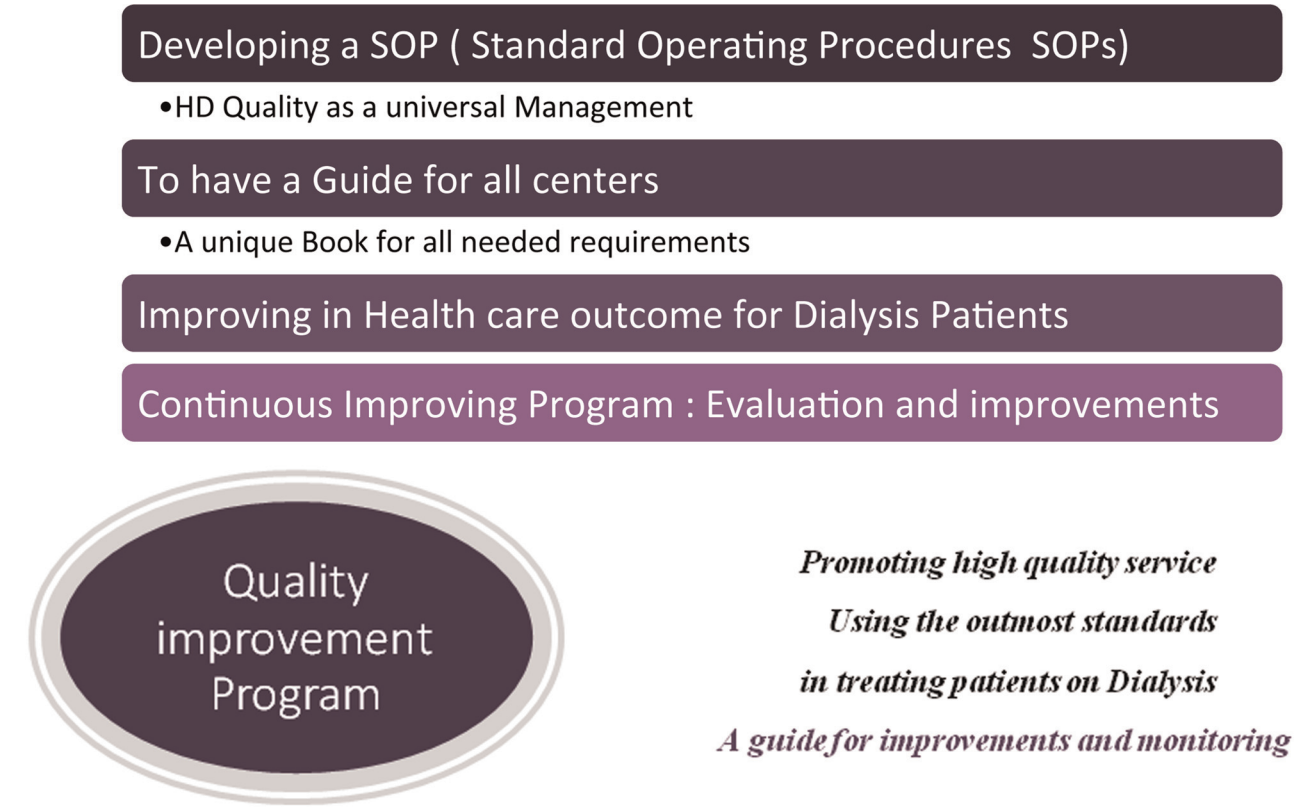
- HD Quality as a universal Management

To have a Guide for all centers

- A unique Book for all needed requirements

Improving in Health care outcome for Dialysis Patients

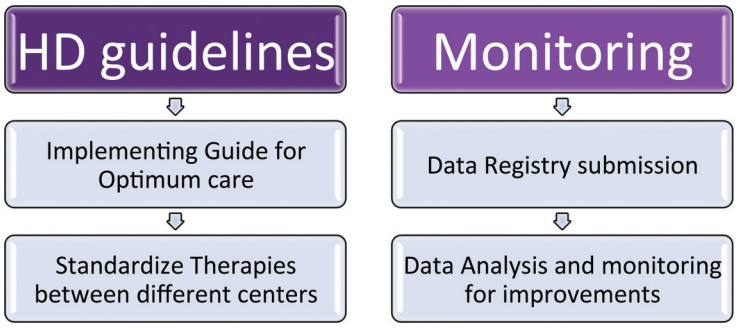
Continuous Improving Program: Evaluation and improvements



Promoting high quality service

Using the outmost standards in treating patients on Dialysis

A guide for improvements and monitoring



The Process of Quality of Care of Hemodialysis units have "3"Major steps

(1) Structure

Designing the Unit in the optimum structure

(1) Hemodialysis Unit should have all the facilities and accessibilities to ensure the safest and efficient process o Hemodialysis. (Structure)

The Basics of the guidelines should be adherent

(1) The process of Hemodialysis should be controled and run in the background of all patients needs and in the optimum quality, and with resonable costs. (Process)

The Accurately Measurements of the Quality of Care

(1) Renal Registries and analysis of different outcomes measurement with scoring of the service and comparatively in between centers. (Outcome)

Guideline 1

Initiation of Hemodialysis

(1) Initiation of Hemodialysis

The decision to initiate maintenance dialysis in patients who choose to do so should be primarily based upon an assessment of signs and/or symptoms associated with uremia, evidence of protein-energy wasting, and the ability to safely manage metabolic abnormalities and/or volume overload with medical therapy rather than on a specific level of kidney function in the absence of such signs and symptoms.

Guideline 2

Hemodialysis Facilities, Equipment and Disposables

(2) Hemodialysis Facilities, Equipment and Disposables
2.1 Hemodialysis Facilities.
2.2 Hemodialysis Equipment.
2.3 Hemodialysis Disposables and Associated Devices.

2.1 Hemodialysis Facilities.

2.1.1 HD facility should have enough specialist support staff to fulfill all the requirements to have safe and efficient hemodialysis therapies.

2.1.2 The travel time to a HD facility should be less than 45 min in different geographical areas.

2.1.3 HD capacity in renal units within a geographical area should increase in step with predicted need for the average patients who need hemodialysis therapies.

2.2 Hemodialysis Equipment.

2.2.1 All equipment used in the delivery and monitoring of therapy should comply with the relevant standards for medical electrical equipment. General safety standards are covered by BS EN 60601-1: 2006 and specific dialysis machine requirements are covered by BS-EN 60601-2-16: 1998 [Medical electrical equipment: requirements for the safety of hemodialysis (HD), hemodiafiltrations and hemofiltration equipment].

2.2.2 Hemodialysis machines should be replaced after between 7- and 10-years' service or after completing between 35 000 and 40 000 h of use for hemodialysis, depending upon an assessment of machine condition.

2.3 Hemodialysis Disposables and Associated Devices.

2.3.1 All disposables are classified as medical devices and should display the CE mark. Should describe the materials used to fabricate all components of the hemodialysis tubing set, including any colorants (e.g. inks, dyes, markings), plasticizers (including di-(2-ethylhexyl) phthalate or DEHP) or additives (FDA guidance, 2008).

The presence of such a mark signifies compliance with the requirements of the statutory Medical Device Directive and also national and international standards where they exist for new products: ISO 8637-1:2017 (Extracorporeal blood circuit for Hemodialyzers, Hemodiafilter and Hemofilters), ISO 8637-2:2018 (Extracorporeal systems for blood purification – Part 2: extracorporeal blood circuit for Hemodialyzer, Hemodiafilter and Hemofilter) and ISO 8637-3:2018 (Extracorporeal systems for blood purification – Part 3: Plasmafilter).

2.3.2 Hemodialysis Concentrates.

(a) Readymade concentrates are classified as medical devices and should display the CE mark.
(b) All solutes in the concentrate should be identified as a medical grade.

(c) We strongly recommend not to use a concentrate with **Potassium** below 2 mmol/l or higher than 3 mmol/l.
(d) We also recommend using a **glucose** containing concentrate (100 mg/dl of glucose) in malnourished patients and in those who experienced frequent hypoglycemia during hemodialysis sessions.
(e) Glucose containing concentrate should not be used in substitution fluids during hemodiafiltration.
(f) Dialysate composition should be adjusted according to the clinical situation of each patient, as is done with other factors that influence the efficacy and safety of hemodialysis.
(g) The concentration of solutes identified on the labelling shall be present to within a margin of ±5% or 0.1 mEq/l, except for sodium and chloride where the margin of variability shall be ±2.5%. These margins are expressed relative to the concentration in the dialysate after dilution of the concentrates, BS EN ISO 13958:2015, BS EN ISO 23500-4:2019.
(h) All the components shall be stated on the labelling along with their quantities and level of purity. The dilution to be used shall be stated as parts of concentrate per parts in the final solution (dialysate). The labelling shall state the expiry date, which guarantees its stability.
(i) We recommend that manufacturers should provide chemical and microbiological quality certificates for the batches of concentrates supplied.

2.3.3 Buffer used during Hemodialysis

(a) The dialysate should contain **bicarbonate** as the buffer.
(b) Acetate buffer is prohibited to be used.
(c) Ideally, the optimal predialysis and post dialysis plasma (HCO_3–) should not be less than 24 mmol/l and not more than 28 mmol/l.
(d) Dialysate bicarbonate affects the rate at which serum potassium levels fall by promoting shifts of potassium into the intracellular compartment.

2.3.4 Dialysate Magnesium

Given the high prevalence of hypomagnesemia, risk associations with mortality, and potentiating effect on potassium shifts,

We suggest standard prescription of higher-**magnesium** dialysate levels of 0.5 mmol/l (1.0 mEq/l), particularly among patients who are hypokalemic and patients subject to large serum-dialysate potassium gradients.

2.3.5 Dialysate Calcium

We suggest using a dialysate **calcium** concentration of 1.25–1.50 mmol/l (2.5–3.0 mEq/l).

2.3.6 Dialysate Potassium

(a) Current evidence most strongly supports the avoidance of low-potassium dialysate less than 2 mmol/l among patients with known predialysis serum potassium levels less than or equal to 5 mmol/l.
(b) The complete avoidance of dialysate **potassium** less than 2 mmol/l or more than 3 mmol/l.
(c) We suggest that use of these dialysate concentrates be accompanied by frequent serum potassium monitoring.

Commonly used Dialysate compositions in canisters (Table 1**):**

Composition of ready-to-use dialysis fluid (after mixing with Bicarbonate concentrate 8.4% and purified water).

Na+ (mmol/l)	K+ (mmol/l)	Ca+ (mmol/l)	Mg+ (mmol/l)	Cl– (mmol/l)	HCO3– (mmol/l)	Acetate (mmol/l)	Glucose (g/l)	Osmolarity (Mosm/l)
138.00	2.00	1.250	0.50	108.50	32.00	3.00	1.00	291
138.00	2.00	1.500	0.50	109.00	32.00	3.00	1.00	292
138.00	3.00	1.250	0.50	109.50	32.00	3.00	1.00	293
138.00	3.00	1.500	0.50	110.00	32.00	3.00	1.00	294

Guideline 3

Water treatment stations and monitoring

(3) Water treatment stations and monitoring:
3.1.1 All centers for hemodialysis should comply with the Egyptian standard for Water Quality, with the Egyptian standard no. 63 for 1996 and revised on February 2019.
3.1.2 All centers should be subjected to water analysis by the Egyptian MOH at least once monthly and should fulfill all the specifications required.
3.1.3 Water treatment is considered the responsibility of each center.
3.1.4 A routine testing procedure for water should form part of the renal unit policy.

3.2 Water treatment station should comply with the following steps:

(1) Water treatment stations should have all the necessary equipment to fulfill the necessary Egyptian standard for water treatment.
(2) In validating the new stations, the following steps should be applied:

2.1 Designing and tendering.

2.2 Purchasing order after full reviewing of the exact needed equipment.

2.3 Performing FAT test (Factory Acceptance Test).

2.4 Performing IQ test: Installation Qualification.

2.5 Performing OQ: Operation Qualification.

2.6 Performing PQ: Performance Qualification.

2.7 Commissioning of engineering or a technician for the maintenance schedule and monitoring (responsibility).

3.3- Daily monitoring of chlorine level and the total dissolved solute is highly recommended.

3.4- Each unit should have standard operating procedures in place for sampling, monitoring and recording of feed and product water quality. The operating procedures should include details of the procedures to be followed if the prescribed limits are exceeded.

3.5- Design of a water treatment system: the basic components of a water treatment system for hemodialysis shall include a pre-treatment, where most of the undesirable elements are removed, and treatment with reverse osmosis and some other element that would achieve the level of purified water as part of its normal operation.

3.6- Pre-treatment shall have at least one filter capable of retaining particles in suspension or sediment, water softener and charcoal filter designed for the characteristics of the feed water supply, with duplicate equipment if levels of the element to be removed are considered high and could cause serious problems in the event of failure.

3.7- The charcoal filter shall always be installed immediately pre-RO, as close as possible, as once the water is dechlorinated, there is a serious risk of contamination, particularly when passing through other filters where the speed slows down.

3.8- When the feed water contains high levels of chloramines and other organic contaminants, or municipal, industrial or agricultural water contamination, the use of two activated charcoal filters in series is recommended.

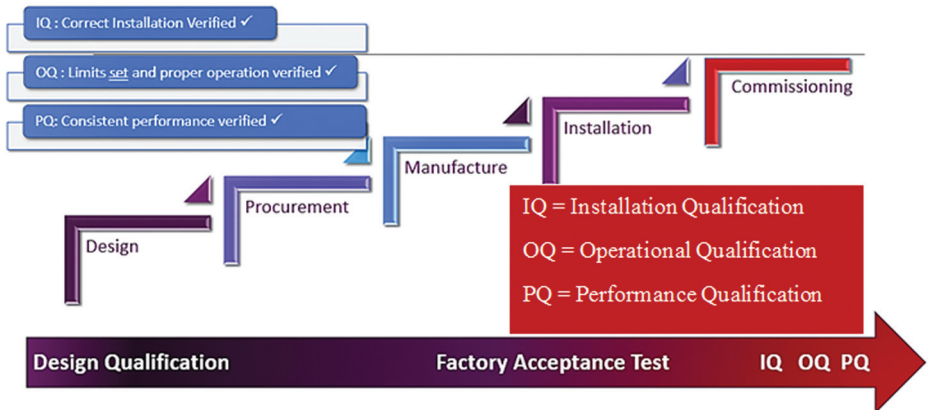
3.9- Osmosis membranes shall be installed post pre-treatment, interposing a filter of at least 5 μm, to avoid the possibility of small charcoal particles passing through, this being an essential element of treatment to obtain water that meets the quality requirements in MOH standards.

3.10- UV lamps should always be used in post treatment stage.

3.11- The water used to produce concentrate for dialysis shall at the very least comply with the standards required for purified water.

A typical validation of equipment/system (Fig. 1)

Figure 1



A typical validation of Hemodialysis Equipment.

Guideline 4

Hemodialysis Membranes and Fluxes

(4) Hemodialysis Membranes and Fluxes
4.1.1 The balance of evidence supports the use of a dialysis regimen with enhanced removal of middle molecules. Treatments with better clearance of middle molecules include hemodialysis with high flux synthetic membranes and hemodiafiltration (HDF).
4.1.2 HDF should be considered a therapy for nonspecific symptoms, including itching, malaise, and poor appetite not responding to high flux dialysis. HDF should enhance the removal of small proteins, reduce the production of inflammatory cytokines, and improve patients' prognoses.
4.2 In order to exploit the benefits of the high permeability of high-flux membranes, on-line hemodiafiltration should be considered, with an exchange volumes should be as high as possible (>23 l for post dilutional mode and >50 l for pre dilutional mode), with consideration of safety for the substitution fluid quality.
4.3 Patients with diabetes, lower serum albumin, or longer dialysis vintage should be considered a priority for selection of high-flux dialysis.
4.4 In general practice, all patients even with low risk, should be recommended to start high flux dialysis and to educate for the benefits of living related transplantation.
4.5 The use of synthetic high-flux membranes should be considered to delay long-term complications of hemodialysis therapy. Specific indications include:
(a) To reduce dialysis-related amyloidosis.
(b) To improve control of hyperphosphatemia.
(c) To reduce the increased cardiovascular risk.
(d) To improve control of anemia.

Guideline 5

Hemodialysis Time and Frequency

(5) Hemodialysis Time and Frequency
5.1 Dialysis should be delivered at least three times per week and the total duration should be at least 12 h per week.
5.2 An increase in treatment time and/or frequency should be considered in patients with hemodynamic or cardiovascular instability.
5.3 An increase in treatment time and/or frequency should be considered in patients who remain hypertensive despite maximum possible fluid removal.
5.4 An increase of treatment time and/or frequency should be considered in patients with impaired phosphate control.
5.5 An increase of dialysis time and/or frequency should be considered in malnourished patients.
5.6 In patients who experienced volume overload and or hyperkalemia in long day interval between hemodialysis sessions, it is recommended to have every other day hemodialysis instead of thrice weekly dialysis to prevent sudden cardiac death.
5.7 The duration of thrice weekly HD in adult patients with minimal residual renal function should not be reduced below 4 h without careful consideration.
5.8 Hemodialysis in pregnancy: pregnant women on regular Hemodialysis should receive at least five sessions per week with a minimum duration of 20 h dialysis per week.
(*Continued*)

(*Continued*)
(5) Hemodialysis Time and Frequency
5.9 Consider additional hemodialysis sessions or longer hemodialysis treatment times for patients with
5.9.1 Large weight gains, high ultrafiltration rates.
5.9.2 Poorly controlled blood pressure.
5.9.3 Difficulty achieving dry weight.
5.9.4 Poor metabolic control (such as hyperphosphatemia, metabolic acidosis, and/or hyperkalemia).
5.10 Safety measures in Extracorporeal circuit.

Definitions of dialysis schedules

Due to high mortality and morbidity rates and, inter and intradialytic symptoms associated with conventional intermittent HD three times a week, different modalities of HD treatment based on variations in dialysis time and frequency have been developed in the last years:

Intermittent conventional hemodialysis (HD):

HD session of 3–5 h three times a week.

Long intermittent HD:

HD session of more than 5.5 h three times a week.

Conventional hemodiafiltration (HDF):

HDF session of 3–5 h three times a week.

Frequent HD (>3 times/week):

Daily (Quotidian) dialysis (at least 6 times/week).

Short daily HD 2–3 h/6–7 times a week.

Long nocturnal daily HD

HD session of 6–10 h/6–7 nights a week.

Daily hemodiafiltration:

HDF session of 2–2.5 h/6 times a week.

5.10 Safety measures in extracorporeal circuits to prevent spallation release and hemolysis should be considered in hemodialysis unit policies.

5.10.1 As a general recommendation from the American Academy of Pediatrics (2003), Health Care Without Harm (2004) and the FDA (2008) plasticizers such has DEHP used with PVC

products (HD and PD tubing) are better replaced with other safer materials particularly in pediatric dialysis due to their documented hazards on fertility and other organs.

5.10.2 Priming of Extracorporeal circuit for Better Safety

If no manufacturer instructions are given, the dialyzers should be pre-rinsed using at least 0.5–1 l of rinsing normal saline 0.9% solution.

5.10.3 Shear stress-related problems and hemolysis can be prevented by:

(a) Considering an optimal relationship between dialyzer blood flow and access diameter.
(b) Preventing highly negative arterial pressure alarms (exceeding 250 mmHg).
(c) Correct positioning of cannula and needles in the access system.
(d) Correct positioning of tubings in the roller pumps.
(e) Minimizing recirculation.
(f) Ensuring appropriate vascular access flow and anatomical conditions.

Guideline 6

Implementing Hemodiafiltration in HD units

(6) Implementing Hemodiafiltration in HD units
6.1 Hemodiafiltration technical requirements and patient choices.
6.2 Types of hemodiafiltration.
6.3 Dose quantification.
6.4 Safety considerations in HDF techniques.
6.5 Specific indications for patients' selection for HDF.
6.6 Hemodiafiltration, barriers to overcome.
6.7 Additional requirements for HDF.

6.1 Hemodiafiltration technical requirements and patient choices:

HDF combines the high diffusive clearance of small molecules obtained in HD with the superior convective removal of larger molecules obtained with hemofiltration.

Online HDF uses a high-flux hemodialyzer with a membrane having an ultrafiltration coefficient more than 40 ml/h/1 mmHg/1 m^2 and a sieving coefficient for **β2-microglobulin of more than 0.6** to deliver a convection volume of at least 20% of the total blood volume processed and should be highly efficient with substitution volume above 23 l per session. Appropriate fluid balance is maintained by the dialysis machines' ultrafiltration control systems and infusion into the patient's blood of a sterile, non-pyrogenic fluid produced online from dialysis fluid.

6.2 Types of hemodiafiltration

6.2.1 **Online hemodiafiltration**: using online preparation of the substitution fluids.

6.2.2 **Offline hemodiafiltration**: using prepackaged bags of sterile substitution fluids.

6.3 Dose quantification (Table 2)

Hemodiafiltration volume	Convection volume (l)	Source of substitution fluid
Low volume	2–12	Prepackaged bags, internal filtration/backfiltration
Medium volume	12–23	Online preparation
High volume	**>23**	**Online preparation**

6.3.1 Volume of substitution fluids.

As the importance of larger uremic toxins has become recognized, the need for alternative therapies that provide better removal of those solutes has become evident. Typically:

(1) The HDF substitution volume should be more than 23 l/session in post-dilutional HDF.
(2) And more than 50 l/session in pre-dilutional HDF.

Increasing the time of HDF sessions is of an additional benefit to reach the goal of substitution volume.

6.3.2 Modes of hemodiafiltration (Table 3):

Post-dilution hemodiafiltration	Ultrafiltration followed by infusion of replacement fluid (Substitution fluid >23 l/session)
Pre-dilution hemodiafiltration	Infusion of replacement fluid followed by ultrafiltration (Substitution fluid >50 l/session)
Mixed dilution hemodiafiltration	Infusion of replacement fluid before and after ultrafiltration (pre-dilution followed by post-dilution)

6.4 Safety for HDF:

It can be argued that equipment used for online convective therapies should be subject to more stringent safety standards and regulatory oversight

than those generally adopted for equipment used for the conventional Hemodialysis.

6.4.1 Filtration Fraction FF % (Table 4)

	Post-dilution		Pre-dilution		
	Effective convection rate (% of blood flow)		Effective convection rate (% of blood flow)		
	20	30	20	30	37.7
Blood flow (ml/min)	UF rate (ml/min)	UF rate (ml/min)	UF rate (ml/min)	UF rate (ml/min)	UF rate (ml/min)
250	50	75	75	150	250
300	60	90	90	180	300
350	70	105	105	210	350
400	80	120	120	240	400
450	90	135	135	270	450

(a) Typical ultrafiltration rates required to achieve effective convection rates of 20%, 30% of blood flow rate with an **FF%**: **UFR/QB (ml/min)**.
(b) Convective transport is achieved by an effective convection volume of at least 20% of the total blood volume processed. Appropriate fluid balance is maintained by infusion of a sterile, nonpyrogenic solution into the patient's blood.
(c) Hemoconcentration generally limits the filtration fraction to 20–25% of the blood flow rate in post-dilution HDF. The ultrafiltration rate is controlled in proportion to the actual blood flow rate or guided by TMP.
(d) A filtration fractions up to 30% of the blood flow rate is possible using systems designed to optimize the filtration rate, based on automatic adjustment of TMP according to the ultrafiltration flow rate measurements.

6.4.2 Considerations in choosing different hemodiafiltration modalities

In theory, post-dilution is the most efficient mode of HDF for clearing middle and large molecular weight substances. **Successful post-dilution HDF depends on:**

(a) High extracorporeal blood flow rates (typically >350 ml/min).
(b) A reliable vascular access (ideally an arteriovenous fistula with a flow rate >600 ml/min).
(c) An ability to achieve adequate anticoagulation throughout the procedure.
(d) And the absence of any condition that increases blood viscosity (high hematocrit, cryoglobulinemia and gammopathies).
(e) When the latter situations occur, pre-dilution or mixed-dilution HDF combined with feedback control of TMP may be more appropriate.

6.4.3 Safety of Substitution Volume

6.4.3.1 The sterile, non-pyrogenic fluid used to maintain fluid balance, referred to as replacement fluid or substitution fluid, can be provided either as a terminally sterilized, packaged solution or as an online prepared solution.

6.4.3.2 Additional risks related to the systems used to prepare the replacement fluid, including the water treatment system, and to control fluid balance are of particular importance to implement a quality control system to check regularly.

6.4.3.3 It can be argued that equipment used for online convective therapies should be subject to more stringent safety standards and regulatory oversight than those generally adopted for equipment used for the conventional hemodialysis.

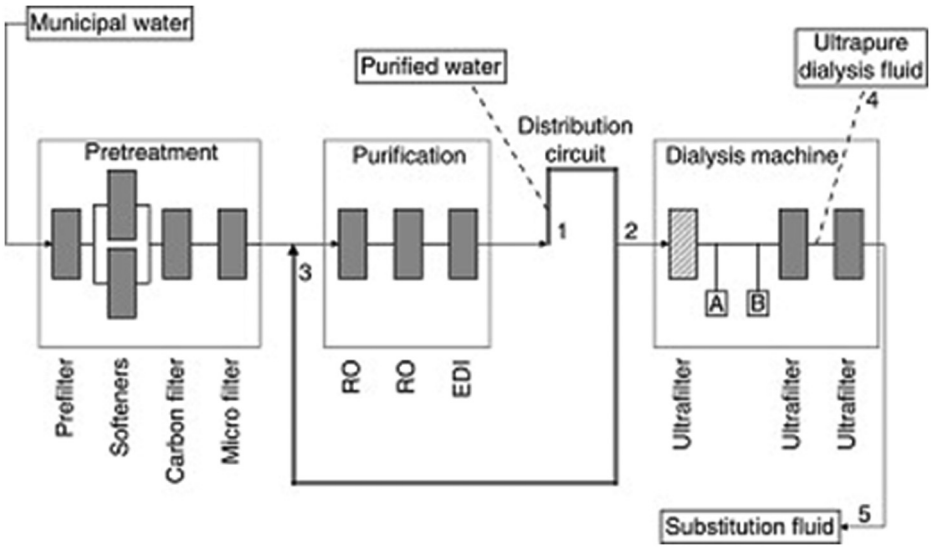
Quality levels for dialysis solutions for hemodialysis (HD) and HDF (Table 5).

	Microorganisms (CFU/ml)	Endotoxins (EU/ml)
Standard HD		
Purified water	<100	<0.25
Dialysis fluid	<100	<0.25
Purified water	<100	<0.25
Ultrapure dialysis fluid	<0.1	<0.03
Substitution fluid	$<10^{-6}$	<0.03

CFU, colony-forming units; EU, endotoxin units

(Fig. 2 Diagram for water treatment for substitution fluid delivery)

Figure 2



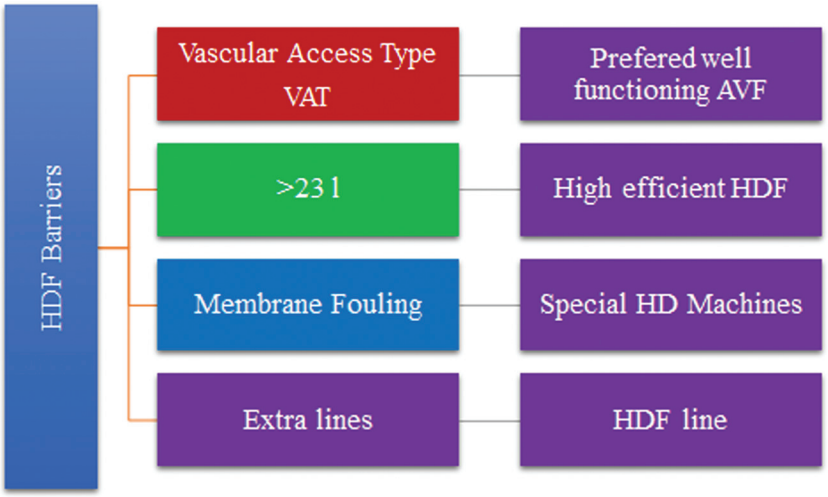
Water treatment for hemodiafiltration.

6.5 Specific indications for patients' selection for HDF:

(a) Patients with residual uremic syndrome despite high flux dialysis.
(b) Patients with B2M amyloidosis.
(c) Patients with sepsis.
(d) Patients with chronic inflammations.
(e) Patients with long standing HD vintage.
(f) Patients with hemodynamic instability.
(g) Nephrologist managing director opinion.

6.6 Hemodiafiltration barriers to overcome (Fig. 3)

Figure 3



Hemodiafiltration Barriers to overcome.

The classification of dialyzers refers to five types, classified to a clearance (*in vitro*) of β2-microglobulin (Table 6**)**

The classification of dialyzers refers to five types, classified to a clearance (in vitro) of β2-microglobulin (Table 6)

β2microglobulin (in vitro)

I < 10 mL/min

II < 30 mL/min

III< 50 mL/min

IV 50-70 mL/min

V ≧70 mL/min

Worldwide classification

High flux Dialyzers for HDF require:

UFR > 40 mL/mmHg/hr

β2MG sieving coefficient (SC) >0.6

β2-microglobulin (*in vitro*)

I less than 10 ml/min.

II less than 30 ml/min.

III less than 50 ml/min.

IV 50–70 ml/min.

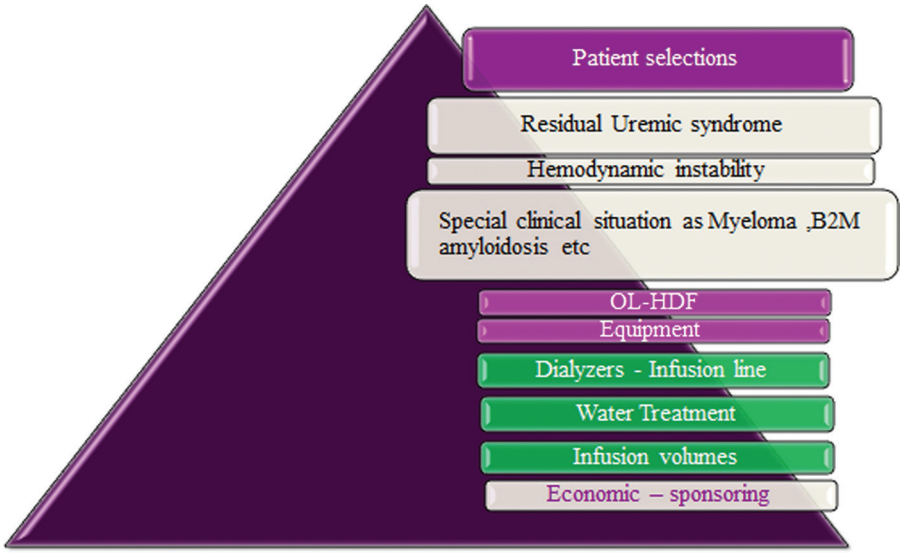
V more than or equal to 70 ml/min.

6.7 Additional Requirements for HDF

6.7.1 Specialized human resources who understand the basics of HDF, dose calculations and risk assessment to carry HDF sessions.

6.7.2 Specific monitoring for the HDF therapies in particular water treatment stations and risk management team.

Figure 4



Approach for Hemodiafiltration.

(Fig. 4 **Approach for HDF program initiation).**

Guideline 7

Hemodialysis Dose Quantification

(7) Hemodialysis Dose Quantification:

7.1.1 Delivered dialysis dose should be measured at least monthly.

7.1.2 Dialysis dose should be measured using a validated method comparable with the reference method. The reference method is formal urea kinetic modeling using predialysis and post-dialysis blood samples.

7.1.3 The recommended delivered dialysis dose for end-stage renal disease patients receiving thrice weekly Hemodialysis should have consistently:

(a) Either urea reduction ratio (URR) more than 65% or
(b) Equilibrated Kt/V of more than 1.2 (or sp Kt/V of 1.4).

7.2 Minimum adequate dialysis with a minimum delivered spKt/V of 1.2.

7.3 Adequacy of hemodialysis using multidimensional measurements.

7.4 Blood flow rate and dialysate flow rate in hemodialysis session.

7.5 Managing suboptimal dialysis adequacy.

7.6 Recovery time after hemodialysis.

Every patient with end-stage renal disease receiving thrice weekly HD should have consistently: either urea reduction ratio (URR) more than 65% or equilibrated Kt/V of more than 1.2 (or sp Kt/V of 1.4) calculated from predialysis and post-dialysis urea values, duration of dialysis and weight loss during dialysis.

The pre-dialysis blood sample must be drawn before injecting saline, heparin, or other potential diluents. The post-dialysis blood sample should be drawn from the dialyzer inflow port using a slow-flow method (100 ml/min for 15 s) or a stop-dialysate-flow method (for 3 min). These measurements should be done at least monthly as recommended in this guideline.

Alternatively, the urea reduction ratio (URR) is easy to calculate and has been used as a standard to measure the delivered hemodialysis dose.

7.2 Minimum adequate dialysis

7.2.1 In anuric patients, treated by three times per week dialysis, the prescribed target eKt/V should be at least 1.2. Higher doses, up to 1.4 should be considered in females and those patients with high comorbidity.

7.2.2 Consider additional hemodialysis sessions or longer hemodialysis treatment times for patients with large weight gains, high ultrafiltration rates, poorly controlled blood pressure, difficulty achieving dry weight, or poor metabolic control (such as hyperphosphatemia, metabolic acidosis, and/or hyperkalemia.

7.3 Adequacy of Hemodialysis using Multidimensional measurements

Factors to be considered in evaluating patients for adequacy of hemodialysis

(a) Urea clearance, by Kt/V or URR%.
(b) Volume control and ultrafiltration rate.
(c) Blood pressure control.
(d) All mineral metabolism biomarkers are in the target ranges.
(e) Clinical symptoms.

Augmented HD schedules:

We recommend that patients with minimal residual function should be treated with high-flux dialyzers.

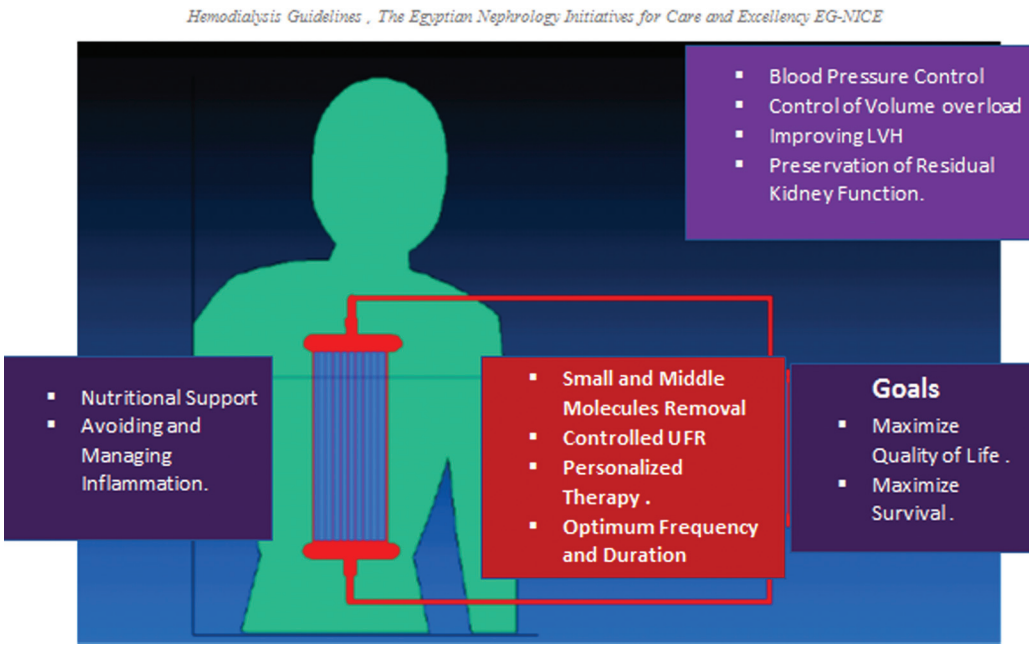
We suggest offering an augmented schedule to patients who are unable to achieve adequacy targets or fluid control on a standard thrice weekly schedule.

We recommend a blood flow rate of 5–7 ml/kg/min for most patients, using consumables appropriate to body size, with extracorporeal volume less than 10% of the patient's blood volume.

For dialysis patients wishing to continue their pregnancy, we recommend changing as early as possible to an individualized, augmented hemodialysis schedule. For those with minimal residual function this should be at least 20 h per week, delivered over at least five sessions with an individualized dialysate prescription appropriate to the dialysis schedule and biochemistry results

In children and adolescents, we recommend an approach to the assessment of dialysis adequacy which goes beyond biochemical targets, incorporating clinical goals such as growth, bone health, cardiac function and quality of life.

Figure 5



Multidimensional approach for Hemodialysis adequacy.

(Fig 5 **Multidimensional Approach for Adequate Hemodialysis)**

7.4 Blood Flow Rate and Dialysate Flow Rate in Hemodialysis Session

Typically, the blood flow rate (QB) in adult patients should be 300 ml/min and above that is specially required when using a big surface area dialyzer.

Blood flow rate (Fig 6 **Blood Flow Rate and AV needle size)**

Standard: more than or equal to 300 ml/min Low flow less than or equal to 300 ml/min.

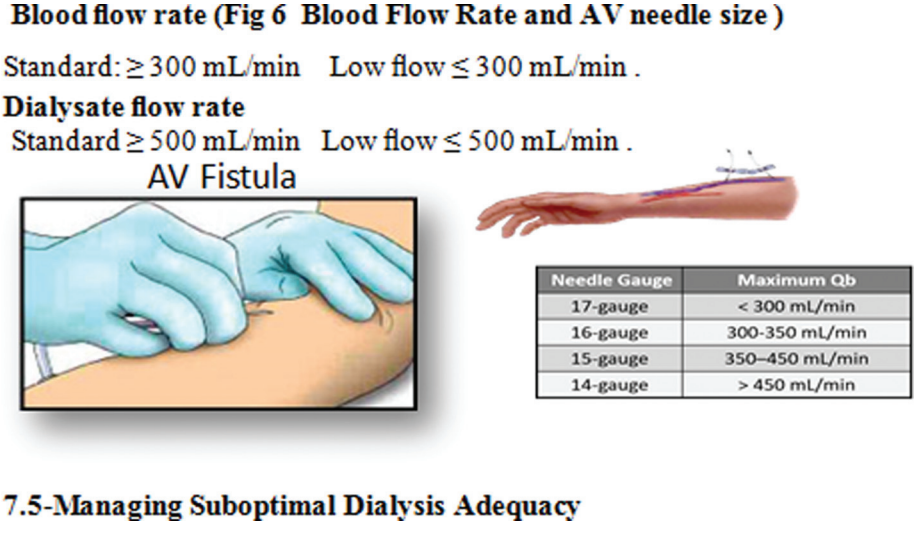
Dialysate flow rate

Standard more than or equal to 500 ml/min Low flow less than or equal to 500 ml/min.

7.5 Managing Suboptimal Dialysis Adequacy

7.5.1 Confirm dialysis inadequacy by assessing procedural issues and vascular access function.

Figure 6



AVF needle size and Blood flow.

7.5.2 Once dialysis inadequacy is confirmed, increase one or more of the following techniques that may be used to increase urea clearance and possibly dialysis adequacy:

(1) Test for access recirculation.
(2) Increase blood flow rate.
(3) Use higher dialyzer KoA.
(4) Prolong dialysis time.
(5) Increase dialysis frequency.
(6) Increase dialysate flow.
(7) Use bigger needle size.
(8) Ensuring adequate anticoagulation.
(9) Do not use isolated ultrafiltration or add it's time to the session length.

7.6–Recovery Time after Hemodialysis

After a hemodialysis session, end-stage renal disease (ESRD) patients on chronic hemodialysis frequently have the following complaints: a sensation of prostration, tiredness, weakness, exhaustion, weariness, or fatigue. Such sensations reduce the capacity to perform common and simple daily activities and impair the patients' well-being.

In patients who experienced long recovery time more than 6 h, pay attention for the HD sessions parameters that include:

(a) Ultrafiltration applied.
(b) Dialysate solute concentration and conductivity applied.
(c) Buffer concentration.
(d) Water treatment stations impurities.
(e) Uses of bioincompatible medical devices.

(Fig 7 **Approach for management of Post dialysis Fatigue and Recovery time**)

Guideline 8

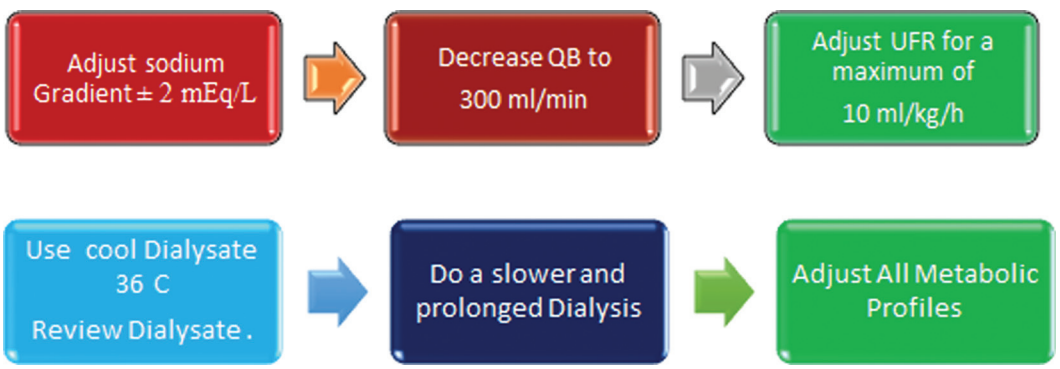
Blood Pressure Control in Hemodialysis Patients

(8) Blood Pressure Control in Hemodialysis Patients
8.1 Standardized BP protocol: BP measured in the seated position for at least 5 min, with an adequately sized cuff and a validated, calibrated monitor.
8.2 If BP measurements are made in the thigh owing to restrictions of upper arm use, supine readings should be used (with the thigh at the level of the heart) to avoid incorrectly high values because of body position.
8.3 Achieve the patient's dry weight: one of the main pathogenic mechanisms of hypertension in dialysis patients is volume (and sodium) overload. This is why targeting this is fundamental for BP reduction in this population.
8.4 The main nonpharmacological measures to reduce volume (and sodium) overload in hemodialysis patients should be carefully implemented before considering pharmacological treatment.
8.5 Diagnosis of hypertension in dialysis patients.
8.6 Management of hypertension in dialysis patients

Factors may lead to inaccurate BP pre-dialysis and post-dialysis readings, such as:

(a) The white coat effects.
(b) Limited time for relaxation (patient impatience to start dialysis and leave the unit quickly)
(c) Fear or anxiety for correct arteriovenous fistula needling.
(d) Previous bilateral upper limb attempts of arteriovenous fistulae.
(e) The unknown validity of most oscillometric devices attached to commercially available hemodialysis machines.
(f) Furthermore, truly high BP variability (pre-dialysis to post-dialysis and day by day variability) in response to fluctuations in volume status and other parameters during the intradialytic and interdialytic periods is another important issue that complicates the accurate diagnosis of hypertension.

Figure 7



Approach for minimizing postdialysis recovery time.

8.5 Diagnosis of hypertension in dialysis patients

Home BP in hemodialysis: an average BP more than or equal to 135/85 mmHg for measurements collected in the morning and in the evening over six non-dialysis days (covering a period of 2 weeks). Measures should be performed in a quiet room, with the patient in seated position, back and arm supported, after 5 min of rest and with two measurements per occasion taken 1–2 min apart.

Main pathogenic mechanisms of hypertension in dialysis patients

(1) Sodium and volume overload.
(2) Increased arterial stiffness.
(3) Activation of the sympathetic nervous system.
(4) Activation of the renin–angiotensin–aldosterone system.
(5) Endothelial dysfunction (i.e. imbalance between endothelium-derived vasodilators and vasoconstrictors).
(6) High prevalence of sleep apnea.
(7) Use of recombinant erythropoietin.

8.6 Management of Hypertension in dialysis patients

8.6.1 First to do:

(a) Avoid positive sodium balance induced by hypertonic dialysate and/or sodium profiling during volume status adjustment.
(b) Reduce dialysate temperature when intra-dialytic hypotension limits ultrafiltration.
(c) If antihypertensive agents are required, select agents with pharmacokinetics suitable for dialysis patients and appropriate for existing comorbid conditions.
(d) Consider longer hemodialysis session duration.

8.6.2 Pharmacotherapy of hypertension in chronic dialysis patients

Evidence to support the preferential administration of one antihypertensive drug class over another for pharmacologic management of hypertension in patients on dialysis is currently missing.

Choice of the appropriate antihypertensive regimen should be individualized and based on:

(a) The BP-lowering efficacy of drugs.
(b) The BP-independent cardioprotective properties.
(c) The intradialytic and interdialytic pharmacokinetics (Drug is Dialyzable or Non-Dialyzable).
(d) The tolerability and side effect profile as well as the comorbidities of each patient.

The use of β-blockers should be strongly considered on the basis of evidence suggesting that these agents likely offer the greatest cardio-protection, including their beneficial actions on regression of LVH and arterial stiffness.

The use of dihydropyridine CCBs as second-line agents when BP remains uncontrolled despite non-pharmacologic measures and β-blockade should be considered.

ACEIs and ARBs are third choices. Dihydropyridine CCBs are useful as combination therapy.

Other drug classes, such as centrally acting agonists, direct vasodilators, and α-adrenergic blockers, are frequently associated with serious side effects, and their use should be limited to patients with difficult to control hypertension.

Post Dialysis dosing or extra doses after HD may be necessary for certain antihypertensive agents:

(1) Angiotensin Converting Enzyme Inhibitors (ACE-I) all are dialyzable except Fosinopril.
(2) Angiotensin Receptor Blockers (ARB), Non are dialyzable.
(3) B-Blockers, Atenolol and Metoprolol are dialyzable but Nebivolol and Carvedilol are Not dialyzable.
(4) Calcium Channel Blockers (CCB) Amlodipine is Not dialyzable

Guideline 9

Guideline on Hemodynamic Instability

(9) Guideline on Hemodynamic Instability
9.1 Definition of intra-dialytic hypotension (IDH)
A proposed definition is a decrease in systolic BP more than or equal to 20 mmHg or a decrease in mean arterial pressure (MAP) by 10 mmHg associated with clinical events and need for nursing interventions.
9.2 A stratified approach to prevent IDH
Hydration state should be regularly assessed by clinical examination. Objective methods to assess fluid state should be considered in a patient with frequent IDH when clinical examination is inconclusive but should not be routinely withheld on the day of hemodialysis treatment.
9.3 Optimizing ultrafiltration: ultrafiltration profiling and blood volume-controlled ultrafiltration.

Measures to assess the hydration state of patients and preventive strategies:

(a) Physical examination should always be the basis for assessment of the dry weight in dialysis patients.
(b) Inferior caval vein diameter, assessed by echography, correlated with blood volume and right atrial pressure and predicted hemodynamic changes during dialysis.
(c) Blood pressure and heart rate should be measured frequently during dialysis in order to anticipate IDH.
(d) Isolated ultrafiltration should not be used as a technique for preventing IDH, isolated ultrafiltration time, if used, should not be included in hemodialysis duration (minimum 4 h hemodialysis).
(e) For patients who experienced hypervolemia, it is recommended to do either more frequent hemodialysis or prolonged (>4 h) to achieve the dry weight and not increasing the ultrafiltration rate above 13 ml/kg/h.
(f) A prolongation in dialysis time or an increase in dialysis frequency should be considered in patients with frequent episodes of IDH.
(g) Use of cool dialysate is mandatory in preventing IDH.
(h) In patients with frequent episodes of IDH, antihypertensive agents should be given with caution prior to dialysis depending on pharmacodynamics.

9.2 Stratified approach to prevent IDH

9.2.1 First-line approach

(a) Dietary counseling (sodium restriction).
(b) Restrict UFR below 10 ml/kg/h.
(c) Refraining from food intake during dialysis.
(d) Clinical reassessment of dry weight.
(e) Use of bicarbonate as dialysis buffer.
(f) Use of a dialysate temperature of 36.0°C.
(g) Check dosing and timing of antihypertensive agents.]

9.2.2 Second-line approach

(a) Try objective methods to assess dry weight.
(b) Perform cardiac evaluation.
(c) Gradual reduction of dialysate temperature from 36.0°C downward (lowest 35°C) or isothermal treatment (possible alternative: convective treatments).
(d) Consider individualized blood volume-controlled feedback.
(e) Prolong dialysis time and/or increase dialysis frequency.
(f) Prescribe a dialysate calcium concentration of 1.50 mmol/l.

9.2.3 Third-line approach (only if other treatment options have failed)

(a) Consider midodrine.
(b) Consider peritoneal dialysis.

9.3 Optimizing ultrafiltration: ultrafiltration profiling and blood volume-controlled ultrafiltration

9.3.1 The recommended maximum ultrafiltration rate is between 10 and 13 ml/kg/h.

9.3.2 Avoid increasing positive sodium balance by 'sodium profiling' or using a high dialysate sodium concentration.

9.3.3 We strongly recommend not to use high sodium dialysate to increase the ultrafiltration rate and the dialysate sodium should be between 134 and 138 mmol/l.

9.3.4 We suggest individualized sodium prescription for intradialytic blood pressure dysregulations according to predialysis serum sodium; dialysate sodium=predialysis serum sodium ±2 mEq/l.

Higher ultrafiltration volumes have been shown to be associated with higher odds of myocardial stunning. In addition, HD itself is associated with decreases in myocardial blood flow that are accentuated by ultrafiltration.

These data suggest that microcirculatory changes are not solely due to reductions in plasma volume and may be caused by other factors as well. Taken together, the above considerations, it is recommended to minimize ultrafiltration rates as best possible in order to maximize hemodynamic stability and tolerability of the HD procedure.

On one hand, high dialysate sodium can lead to inadequate sodium removal during dialysis, resulting in higher interdialytic weight gains and hypertension, necessitating higher ultrafiltration targets, and, if unable to achieve these targets, chronic volume overload occurs. On the other hand, lower sodium dialysate is associated with greater likelihood of hemodynamic instability during HD and thereby

may predispose to inadequate fluid removal and subsequent volume Overload

Guideline 10

Standard Operating Procedures (SOPs) for the management of a patient's Hemodialysis Care

(10) Standard Operating Procedures (SOPs) for the Management of a Patient's Hemodialysis Care
10.1 SOP for Pre-dialysis assessment.
10.2 SOP for care during dialysis.
10.3 SOP for post dialysis care.
10.4 SOP for managing patients who shorten their dialysis session.
10.5 SOP for managing difficulties in achieving prescribed blood flow.
10.6 SOP for administration of blood transfusion during dialysis.
10.7 SOP to guide weight and blood pressure management on dialysis.
10.8 SOP for managing hypotensive episodes during dialysis.
10.9 SOP for managing cramps during hemodialysis.
10.10 SOP for management of headache on hemodialysis.
10.11 SOP to guide management of nausea and vomiting during hemodialysis.
10.12 SOP for management of air embolism during hemodialysis.
10.13 SOP for management of clotted circuit causing blood loss.
10.14 SOP for management of dialyzer blood leak during hemodialysis.
10.15 Standard conditions for blood sampling.

10.1.1 SOP for pre-dialysis assessment, care during dialysis and after completion of dialysis. On arrival, the patient can expect to see clearly displayed where they will be seated, the approximate time their machine will be ready and the nurses who will be caring for them on the shift.

The patient can generally expect to be started on dialysis within 30 min of their allocated appointment time. Occasionally unexpected situations may occur which cause delay, and this will always be communicated to the patients by the clinical team with an updated estimate for the dialysis start.

During the patient's dialysis session, they can always expect a registered nurse (RN), with experience and skills in dialysis to manage their care.

10.1.2 Pre-dialysis assessment

Once the patient's dialysis machine and station are sufficiently ready for the patient to be able to settle down and be seated comfortably, a nurse will call the patient from the waiting area. Any special isolation or machine preparation needs to be checked and as ready as possible, before hand to ensure patients are dialyzed safely and in the correct cohort.

For those patients that have an AVF/G, the patient will be asked to wash the relevant limb, along with their hands, with soap and water, before entering their dialysis station area. Assistance will be provided if required. Patients dialyzing via a renal dialysis catheter (RDC) will be asked to wash their hands.

All patients should also be weighed before entering their dialysis area. Again, they will be encouraged to perform this aspect of their care themselves with help given as required.

For those that can weigh themselves and carry out and record their observations and those self-caring, encourage those that can do so. Ensure patients are aware of where and how to document the observations.

10.1.-3 Pre-dialysis observations will be performed and recorded:

(1) Seated blood pressure. Ensure seated for at least 5 min and correct cuff size.
(2) Pulse rate.
(3) Temperature.
(4) Respiratory rate.

10.1.4 Before start of dialysis, assess and question the patient taking particular note of any changes since last session:

(a) Mobility.
(b) Pain.
(c) Skin state.
(d) Any edema.
(e) Signs of bruising/bleeding.
(f) Overall well-being including change in general health since last session and whether the patient has complaints or signs and symptoms of infections.

10.1.5 Review information from previous dialysis session:

(a) Note pre and post dialysis observations.
(b) Note any recorded dialysis variances.

10.1.6 Review of baseline information:

(a) Weight gain – ideally less than 5% of prescribed dry weight.
(b) If weight gains are higher than this: educate patient in safe fluid intake, diet and how to

reduce high salt intake foods. Use dietitian as needed and consider discussion with careers/ family.
(c) Review whether there has been a reduction in native urine output; perform 24-h collection (collected in inter-dialytic period). Consider furosemide prescription in those with native urine output.
(d) If diabetic, review blood glucose levels, as if high this may increase thirst and the need for fluids.
(e) If persistently finishing dialysis above dry weight, consider the need for reassessment.
(f) Consider use of blood volume monitoring if available, to help assess fluid status.
(g) If weight gains become less than previously, consider need to reduce dry weight.
(h) If patient reports increasing subcutaneous edema or shortness of breath prior to a dialysis session, consider dry weight reduction.

10.1.7 Blood pressure measurement

(a) Ideally less than 140/80 mmHg. Acceptable up to 160 systolic and 90 diastolic. Higher systolic may be acceptable in patients with a wide pulse pressure and where rapid falls occur with dialysis.
(b) If BP has been gradually increasing, then consider whether dry weight reduction is required.
(c) If BP persistently more than 160/90 then obtain some inter-dialytic recordings for review by consultant. Ensure up-to-date information on antihypertensive medications and doses.
(d) If BP is markedly lower than previous pre-dialysis recordings consider whether patient is unwell; for example sepsis, dehydration. Seek advice.

10.1.8 Pulse Recording

(a) Ideal pulse rate is 60–100 bpm and should be comparable with previous pre-dialysis recordings.
(b) Feel rhythm manually to check pulse is regular in addition to machine recording.
(c) Outside of this range consider dehydration, sepsis, cardiac arrhythmia.

10.1.9 Temperature Recording

Ideally 36.5–37.2°C and should be comparable with previous pre-dialysis recordings.

(a) Outside this range consider sepsis, hypothermia.
(b) Ensure no obvious access infection following central venous access devices protocol.
(c) Question as to whether patient has been systemically unwell at home, for example, fevers, rigors, poor appetite.
(d) Question patient with regards to localizing symptoms of infection (e.g. ear, throat, coryzal, cough), diarrhea and vomiting, urinary, skin breaks). Take skin swabs, urine cultures if indicated.
(e) Follow blood culture procedure.
(f) Discuss with unit consultant for proper management.

10.1.10 Calculate fluid removal and dialysis plan

(a) Based on observations and patient clinical assessment.
(b) Ensure patient understands the need for any re-setting of dry weight or other changes to treatment.
(c) Review and prepare for any pre dialysis testing.

10.1.11 Assess patient's access and follow

Appropriate SOP for access preparation as per access protocols. See 'Guidelines for the cannulation, monitoring and surveillance of arteriovenous fistula and arteriovenous graft for the purpose of Hemodialysis' or 'Guidelines for the care of central venous access devices.'

10.2 Care during dialysis

Adequate observations will prevent unexpected dialysis emergencies, needle dislodgment and clotted circuits.

10.2.1 Perform observations (BP, P, R and record machine parameters, dialysis progress and medications administered, etc.). The frequency of observations should be risk assessed. In very stable patients who normally have no adverse dialysis events requiring intervention; observations can be taken pre, midway and post dialysis. Patients that are less stable will require as a minimum hourly observation.

10.2.2 Patients that are diabetic will require additional blood sugar monitoring, as a minimum pre and post dialysis (using at the point of care monitors).

10.2.3 Routine drug rounds should be completed for example iron and erythropoietin.

10.2.4 Prepare and administer any extra prescribed medication as per protocols for example antibiotics.

10.2.5 Chase any recent test results and ensure appropriate action is taken.

10.2.6 Ensure the transport for patient's return journey is arranged.

10.2.7 Train patient in self-care/shared care competencies if interested.

10.2.8 Spend time discussing any medical issues with the patient and updating their kidney care plans; help them understand their blood results and dialysis prescription suggesting self-management strategies to make aid improvements. Refer to dietitian if needed.

10.2.9 Discuss any psychosocial issues referring to welfare support or psychological support service if needed.

10.2.10 Ensure patients and careers are aware of any approaching outpatient clinics and their time and location arranging transport if needed.

10.2.11 For patients that are on Warfarin, ensure INRs have been taken as scheduled with the result and new dosing conveyed to the patient.

10.3 SOP for Post dialysis care

10.3.1 As dialysis is approaching completion, prepare equipment ready to terminate dialysis and disconnect the patient from the machine.

10.3.2 Obtain any required post dialysis blood samples (SOP for obtaining blood samples from patients on hemodialysis).

10.3.3 Disconnect access as per protocols. 'Guidelines for the cannulation, monitoring and surveillance of arteriovenous fistula and arteriovenous graft for the purpose of hemodialysis' and 'Guidelines for the care of central venous access devices.'

10.3.4 Where possible, encourage patients to be involved in these procedures. See SOP 'Supporting a patient to remove their dialysis needles' in 'Guidelines for the cannulation, monitoring and surveillance of arteriovenous fistula and arteriovenous graft for the purpose of hemodialysis.'

10.3.5 Ensure the patient is aware of keeping their exit site dressing dry and procedures to follow, if the catheter become dislodged, bleed or they feel unwell.

10.3.6 For patients with AVF or AVG, ensure the patient is aware of procedures to follow if any bleeding between sessions.

10.3.7 Post dialysis observations (BP, P, R, Temp and blood sugar in diabetic patients) are to be recorded before the patients dismounts the chair/bed.

Where a patients systolic BP is less than 110 mmHg systolic, ask the patient to wait a further 5 min and repeat. If after been seated for a further 15 min and the patient is symptomatic of a low blood pressure, refer to the consultant.

10.3.8 Ensure all patients are aware of who and how to contact in the case of any emergency.

10.3.9 Administer Hepatitis B vaccination if required

10.3.10 Complete any outstanding documentation and record in diary any issues to be chased during next session.

10.4 SOP for managing patients who shorten their dialysis session

Patients who shorten their prescribed dialysis session endanger their health.

10.4.1 Try and establish the reason for shortening of session:

(a) Does the patient have an important commitment elsewhere at that particular time, for example, financial requirements, job interview or other medical appointment?
(b) If there are financial, family/career responsibilities that are regularly causing treatment shortening consider discussion with financial aids with patient's permission.
(c) If patient states they are unwell, try to establish if further medical help is required. If necessary, discuss further with unit consultant for advice.
(d) If patient is low in mood and finding dialysis difficult consider psychological referral with patient's permission.

10.4.2 Empathsize with the patient, offering encouragement to complete prescribed treatment.

10.4.3 Offer advice on staying safe according to the patient's needs. Ensure that they know how to seek further help if they become unwell, for example through local Accident and Emergency Department, via own dialysis unit.

(a) Give advice with regards to fluid overload: ensure the patient knows how to recognize signs of fluid overload (breathlessness, unable to walk normal distances, unable to lie flat to sleep) and how to seek help, and that they are very careful with fluid intake.
(b) Give advice with regards to potassium intake if relevant. Advise patient to be particularly careful with potassium rich foods. Advise that signs of high potassium may be weakness and aching in limbs but that dangerous levels can also occur without symptoms.
(c) Document in the patient's medical records of their treatment shortening, any discussion with the patient, actions taken, and register as a treatment variance as per local protocols.
(d) Ensure unit consultant is aware of patient's shortening of treatment.
(e) Ask patient to sign 'Early termination of dialysis' form.

10.5 SOP for managing difficulties in achieving prescribed blood flow

In order to achieve adequate dialysis, it is important that the blood flow (QB) achieved from vascular access is sufficient to allow adequate toxin clearance and fluid removal. If blood flow is suddenly lower than expected the procedure below should be followed.

Exceptions

(a) The fistula is newly formed, assessed as sufficiently mature and within the first 2 weeks of needling with a reduced blood flow.
(b) Patients with cardiac/medical problems that have a prescribed lower blood flow.

Actions: Blood flow is less than 200 ml/min.

10.5.1 General:

(a) Check tubing for kinks and straighten tubing if needed.
(b) Resume blood pump. If prescribed blood flow is achieved – no further action is needed.
(c) If blood flow remains at less than 200 ml/min – consider fluid challenge by infusing boluses of 0.9% sodium chloride or online substitution fluid (150–200 ml) if felt to be below true dry weight. Re-assess dry weight.
(d) Consider whether to continue treatment session at such low blood flow. Check spot potassium level to ensure safe to terminate dialysis. Discuss any results or outcomes with the patient's consultant.
(e) Review anti-coagulation prescription; dosing may need to be increased if there is evidence of clotting in the circuit.
(f) Ensure close observation of circuit, document treatment and actions. Ensure any necessary follow up.

10.5.2 For patients with AVF/AVG:

(a) Stop blood pump. Recheck position of needles, flush needles with 0.9% sodium chloride for injection. If AVF/G does not flush, refer to Access Team urgently.
(b) Refer to protocols in 'Guidelines for the cannulation, monitoring and surveillance of arteriovenous fistula and arteriovenous graft for the purpose of Hemodialysis' for further guidance on assessment and management of AVF/AVG problems.

10.5.3 For patients with a vascular catheter:

(a) Stop blood pump. Re-position the patient and flush lumens with 0.9% sodium chloride for injection. If dialysis catheter does not flush, follow the guideline 'Administration of urokinase into tunneled Hemodialysis catheters.'
(b) If a blood flow is achieved but still below the patient's prescribed blood flow, consider intra-dialysis infusion as per 'Administration of urokinase into tunneled Hemodialysis catheters.'

10.6 SOP for administration of blood transfusion during dialysis

Introduction

(a) Stored red blood cells (RBC) in bags of blood ready for transfusion, can contain more than 20 mmol/l of potassium. Because of this potential risk of high and unknown levels of potassium, patients with ESKD requiring a blood transfusion should, if at all possible, receive blood transfusions during a dialysis session.
(b) In addition, it is safe practice to administer blood in the form of packed red blood cells rather than whole blood; the administered volume is added to the total fluid loss required during the dialysis.
(c) All other aspects and polices related to sampling, prescribing, checking and administering blood for transfusion must be followed and no safety measures breached.

Administration of Blood for Transfusion during Dialysis

How?

Administer all blood transfusions via the arterial port in the dialysis blood circuit. This ensures it is passed through the dialyzer removing some of the additional potassium before reaching the patient's circulation.

Time?

(a) Administer each unit over 45–60 min.
(b) Ensure dialysis continues for 30 min after the last unit of blood has finished.

Anticoagulation?

(1) Administer as normal prescription.
(2) For patients that are not prescribed anticoagulation, additional flushes of the dialysis circuit with 0.9% sodium chloride for injection or on-line substitution fluid may be required.

Fluid consideration?

Ensure the blood volume administered is also calculated into the total fluid volume to be removed/ultrafiltrated.

10.7 SOP to guide weight and blood pressure management on dialysis.

Fluid removal (ultrafiltration) during dialysis

In order to prevent precipitation of hypotension, which would occur when fluid removal from the vascular compartment exceeds the ability of the physiological compensatory response, and is associated with changes in myocardial blood supply and poor outcomes, UFR can only be performed at a maximum rate of 10–13 ml/kg/h.

10.7.1 Assessment of residual urine output. It should be measured within a month of commencing chronic hemodialysis and every 6 months thereafter. Furosemide should be used to help maintain urine output. In addition, nephrotoxic drugs should be avoided in patients with residual renal function.

10.7.2 Insensible loss (i.e. fluid lost through sweating and the gastrointestinal loss) is ~750 ml/day. This may be greater in hot weather or in patients with higher than average activity levels. Individualized fluid intake guidance should be developed. In an anuric patient this generally amounts to a 1000 ml/day fluid restriction but will obviously depend on the patient's size. This can be increased in a patient passing urine.

10.7.3 Calculated fluid removal should be based on the patient's dry weight. However, ultrafiltration rates should not be higher than 10–13 ml/kg/h. This is often misquoted as '1 l/h' but of course will depend on the patient's dry weight (a 50 kg patient is very different from a 120 kg patient) and other co-morbidities affecting tolerance to rate of fluid removal.

10.7.4 Effective estimation of dry weight is important and should be reviewed regularly. This can be difficult and should be based upon blood pressure changes (using sitting and standing if necessary), central venous pressure, peripheral edema, any symptoms of pulmonary edema and bioimpedance measures if available. Senior nursing staff should be skilled to adjust dry weight and all nursing staff should be able to communicate the need to adjust dry weight effectively to patients.

10.7.5 If fluid removal results in hypotension or symptoms of hypovolemia above dry weight various methods can be utilized to aid adequate fluid removal:

(a) Consider use of blood volume monitoring to guide ultrafiltration.
(b) Use HDF if not already prescribed.
(c) Advise against eating and drinking during dialysis.
(d) Consider alternative ultrafiltration schedules. Sodium profiling should not be used as tends to sodium load patients and worsen interdialytic fluid gains.
(e) If hypotension occurs at the beginning of dialysis, consider a fluid bolus at start of dialysis.
(f) Consider lowering temperature of dialysate to 36°C or even 35.5°C. Further reduction is unlikely to be helpful.
(g) Consider cautious changes in dialysate sodium following discussion with unit consultant.
(h) If patient is still not able to tolerate removal of gained fluid, then consideration should be given increased frequency of dialysis. This can be performed in center if short term to allow 're-setting' of dry weight or if serious co-morbidity, but consideration should also be given to home Hemodialysis to allow regular increased frequency dialysis.
(i) In intractable cases, periods of isolated UF may need considering although this will extend length of dialysis session.

10.8 SOP for managing hypotensive episodes during dialysis

10.8.1 Introduction:

Hypotension on dialysis can have several causes. In an individual it may be multifactorial:

(a) When the rate of fluid removal exceeds vascular refilling rate. This is more likely to occur when ultrafiltration exceeds the rate of 10 ml–13 ml/kg/h and when fluid gain between dialysis sessions is excessive.
(b) When a dry weight is not correct and is too low.
(c) When antihypertensive medication or medication affecting the pulse, rate does not allow physiological adaptation to fluid removal.
(d) With significant cardiac disease preventing physiological adaptation to fluid removal. This includes significant left ventricular failure, dialysis-induced ischemia and rhythm abnormalities.
(e) When a patient has significant extra-renal fluid losses resulting in reduced intravascular volume either temporarily, for example diarrhea and vomiting, blood loss on dialysis or long term, for example high output ileostomy.
(f) With serious infection particularly sepsis syndrome.
(g) As a chronic condition in long term, particularly anephric patients.

10.8.2 Immediate action if clinically significant hypotensive episode occurs:

(a) Place the patient in the Trendelenburg position.
(b) Stop ultrafiltration and re-assess fluid loss. Keep off ultrafiltration for at least 10–15 min.
(c) Administer oxygen.
(d) Administer 150 ml bolus of sodium chloride 0.9% or online substitution fluid if clinically necessary.
(e) If recovery not within 5 min, consider need for medical review.

10.8.3 Prevention:

(1) Ensure all patients have a personalized fluid intake guide that they understand. Engagement of other family members/careers may be necessary. This should be reassessed regularly considering residual urine output, size, degree of physical activity and any other fluid loss. Dietetic advice should be employed to aid salt and water intake.
(2) Regular assessment of dry weight using clinical parameters and bioimpedance measurements if available.
(3) Regular assessment of use of antihypertensive medications. Pre-dialysis blood pressure is only a snapshot of blood pressure control over 48 h and should be treated in context of other measurements. There is little evidence to suggest that dialysis patients should have the same degree of BP control as within the non-dialysis CKD population.
(4) Consider alternative scheduling of medication such as after dialysis or on non-dialysis days.
(5) Additional measures:
    (a) Consider use of HDF if not already prescribed.
    (b) Consider use of blood volume monitoring to guide ultrafiltration.
    (c) Consider full cardiac assessment to identify severe left ventricular failure, valvular abnormalities, marked ischemia or rhythm abnormalities.
    (d) Consider further cooling of dialysate; it is unlikely that reduction to below 35.5°C will be helpful.
    (e) Consider increasing frequency of dialysis in patients with significant cardiac disease.
    (f) Consider home Hemodialysis and increased frequency/prolonged hours dialysis for patients who struggle with interdialytic weight gains.
    (g) Consider cautious changes in dialysate sodium.
    (h) Consider alternative ultrafiltration schedules. Sodium profiling should not be used as tends to sodium load patients and worsen interdialytic fluid gains.
    (i) Advise against eating and drinking during dialysis.
    (j) If hypotension occurs at the beginning of dialysis, consider a fluid bolus at start of dialysis.

10.8.4 In patients with chronic hypotension;

(a) Perform cardiac work up to rule out cardiac causes.
(b) Perform short synacthen test.
(c) Consider use of midodrine, ephedrine, fludrocortisone.
(d) Use HDF not standard HD.
(e) Consider suitability for more frequent dialysis whether at home or in center.
(f) Consider use of compression stockings.
(g) Ensure very close observation of dialysis access; lower BP may accentuate hemodynamic effects of any vessel stenoses.

10.9 SOP for managing cramps during Hemodialysis

10.9.1 Introduction:

Patients may complain of cramp at varying times during their dialysis session. Mostly the cramp is felt in the lower calf muscles, but it is not uncommon for cramping pain to be felt in hands, feet, abdomen, etc. This can vary from mild to extreme pain and muscle spasm.

10.9.2 Causes (these are often multifactorial but commonly):

(a) Excessive fluid removal due to; large interdialytic fluid gains.
(b) Incorrect dry weight.
(c) Poor circulation – unable to adequately perfuse extremities.

10.9.3 Signs and symptoms of physiological complications secondary to rate of fluid removal:

(a) Often the patient recognizes no symptoms.
(b) Gradual hypotension during dialysis session.
(c) Yawning.
(d) Muscle tightening and cramps.

10.9.4 Dialysis management of severe cramps:

Immediate:

(a) Reduce ultrafiltration rate.
(b) Reduce blood flow rate.
(c) Massage limb if possible.
(d) Administer oxygen.
(e) Administer 0.9% sodium chloride (or machine prepared solution) in measured boluses.
(f) Re assess fluid removal and patient's dry weight.

Then:

(a) Re-educate patient fluid intake if weight gain is excessive.
(b) Measure native urine output and maximize with diuretics.
(c) Refer to dietitian to review sodium intake.
(d) Consider use of quinine sulphate.

10.10 SOP for management of headache on Hemodialysis

10.10.1 Causes of headache during dialysis:

(a) Disequilibrium.
(b) Blood flow too fast.
(c) Hypertension.
(d) Reduction in caffeine levels.
(e) Magnesium deficiency.
(f) Dehydration.
(g) Dialysate sodium levels too high.
(h) Causes unrelated to dialysis.

10.10.2.Intervention:

(a) Check observations – treat cause if able using listed interventions.
(b) Discuss with consultant if blood pressure markedly raised.
(c) Administer prescribed analgesia.
(d) Consider reducing blood flow (but no <250 ml/min).
(e) Reassess fluid removal and dry weight (if considered too low). See 'SOP to guide weight and blood pressure management on Hemodialysis.'
(f) Consider stopping ultrafiltration until headache has settled.
(g) Consider changing from HD to HDF.
(h) Dim lights.
(i) Treat magnesium deficiency.

10.11 SOP to guide management of nausea and vomiting during Hemodialysis

10.11.1 Introduction:

Nausea and vomiting during dialysis can occur for a number of reasons:

(a) Motion sickness from the journey to dialysis.
(b) Food consumed just before or during dialysis. Dialysis may divert blood flow away from the gut.
(c) Rapid fluid removal.
(d) Hypotension.
(e) Non-dialysis related reasons, for example intercurrent illness.

10.11.2 Prevention and management:

(a) Address any intercurrent illness, seeking medical advice if required.
(b) Advise patient not to eat prior to and during dialysis.
(c) If nausea is related to travel, consider prescribing anti-emetics for the patient to take prior to commencing their journey.
(d) Commence dialysis slowly, increasing blood flow during first 30 min of treatment.

(e) If related to hypotension or excessive fluid removal refer to 'SOP to guide weight and blood pressure management on Hemodialysis.'

10.12 SOP for management of air embolism during Hemodialysis

10.12.1 Introduction:

There is a risk of air embolism during the preparation of the patient's dialysis access and via the dialysis machine blood circuit. It is a serious event, with the symptoms and consequences depending on the site of passage of the air embolus within the circulation. It can lead to peripheral circulatory obstruction, convulsions, stroke or a cardiac event. The risk of air embolus is increased if the patient/nurse repeatedly silences an air alarm. During an air alarm both the venous and arterial machine line clamp close. Overriding these alarms re-opens the clamps allowing the blood flow and air to either flow backwards up the arterial line or past the venous aid chamber to the patient.

10.12.2 Air emboli may occur:

(a) During preparation of the dialysis catheter; if the dialysis catheter is not clamped when the end cap is removed, air may enter into the patient's circulation.
(b) If dialysis needles/access are dislodged air may enter the circulation.
(c) Via the dialysis circuit; when the dialysis circuit lines and catheter or needle connections are not secured adequately, or the dialysis circuit is not primed thoroughly, air may enter the patient's circulation.
(d) Once in 'dialysis mode' should air enter the blood circuit, this will be detected and stopped from entering the patient via the venous air detector. However, if air enters via the arterial line of the dialysis blood circuit before the blood pump, it is possible for this air through gravity, to flow back to the patient if the patient be lying/sat lower than the blood pump.

10.12.3 Preventing air from entering the patient and causing an air embolism:

(a) Ensure all connections (blood circuit, dialysis/fistula tubing to dialysis circuit, clamps, caps) are closed and capped.
(b) Ensure dialysis catheter is not cracked and that clamps function correctly to seal the ends of the lumens.
(c) Ensure venous dialysis circuit line is securely placed in venous air detector and air detector and line clamp function correctly.
(d) Monitor any infusions carefully and where possible add these via venous air chamber. Packed red cell transfusions should however always be infused via the arterial port.
(e) Where possible have patient lying/sat above the level of the blood pump.

10.12.4 Recognizing air in the dialysis machine circuit:

(a) Visible air is detected in the dialysis circuit en-route to the patient.
(b) Venous air chamber alarm recognizes air in the circuit.

Management of identifying air in the dialysis machine circuit:

(a) Stop the blood pump, clamp the blood lines.
(b) Disconnect the arterial and venous lines from the patient and re-circulate the blood lines.
(c) Flush the patients access with 0.9% sodium chloride for injection.
(d) Circulate the blood circuit until all evidence of air has been removed, by collecting it in the venous air chamber.
(e) When there is no further evidence of air in the circuit, reconnect the patient and re commence dialysis.

10.12.5 Recognizing an air embolism:

Patient complains of sudden chest pain, shortness of breath, cyanosis, seizure, cardiac/respiratory arrest.

10.12.6 Management of an air embolism:

(a) Stop blood pump and clamp blood lines.
(b) Place patient on left side with head lower than their heart (Trendelenburg position).
(c) Administer 100% oxygen.
(d) Call for help and medical support.
(e) Monitor and record pulse, respirations, blood pressure and oxygen saturations.

10.13 SOP for management of clotted circuit causing blood loss

10.13.1 Introduction

A dialysis extracorporeal circuit (containing blood lines and a dialyzer) contains between 200 and 300 ml. This

blood-filled circuit can clot at any stage resulting in blood loss to the patient.

10.13.2 Measures to minimize the risk of clotting within the circuit include:

(a) Ensuring adequate anticoagulation is used.
(b) Maintaining optimal blood flow.
(c) Removing fluid within the patients safe/tolerated limits (no >5% of body weight or 10–13 ml/kg/h.)
(d) Ensuring that the dialysis machine tests are complete and passed, indicating the machine is safe to use.

10.13.3 Signs to help recognize when a circuit may be clotting are:

(a) Venous blood returning is much darker than blood in arterial line or pre dialyzer.
(b) Blood clots and line of blood is visible around venous chamber.
(c) Venous pressure increases.
(d) Transmembrane pressure (TMP) rises.
(e) Air detector alarm is activated.

10.13.4 Actions if dialysis circuit is thought to have clotted:

(a) Ensure access is still patent and flush with 0.9% sodium chloride for injection.
(b) Establish reason for clotted circuit, such as inadequate anti-coagulation, over-excessive ultrafiltration, blood flow less than 200 ml/min, rising venous pressure, dropping arterial pressure, rising trans-membrane pressure (TMP), high hemoglobin, etc.
(c) Once the clotted circuit reason/cause has been identified, re-prime a new set of blood lines and ensure no further loss of blood through clotting occurs again.
(d) Where necessary rehydrate the patient, by infusion 0.9% sodium chloride for injection to the volume of blood lost if required.
(e) At the patients next dialysis session, check hemoglobin if the previous result is less than 10 g/dl and if loss is greater than 100 ml.
(f) Complete documentation and incident report, indicating estimated blood loss volume.
(g) Discuss incident with the patient.

10.14 SOP for management of dialyzer blood leak during Hemodialysis

10.14.1 Introduction:

Rupture of a dialyzer membrane can occur due to:

(a) Dialyzer being dropped.
(b) Application of excessive trans-membrane pressure (TMP) (during isolated UF or excessive fluid removal, coupled with high venous pressure).
(c) Clotting of the blood circuit.
(d) Clotting of the dialyzer.

Careful observation of the blood circuit for color, clots and monitoring of the TMP by ensuring the maximum pressure according to the manufacturer is not exceeded, should ensure any leak is prevented. In addition, dialysis machines use an optical sensor to detect any passing of blood into the dialysate compartment by looking for a color change in what should be clear fluid.

False alarms (which activate the machine alarm system as if it were a true blood leak), can be caused by tiny air bubbles passing through the intact membrane. This is generally caused by inadequate priming before dialysis has commenced or air which has entered the blood circuit during the treatment requiring 'recirculating' until all air is removed, and the alarm cleared.

10.14.2 What happens following a blood leak alarm?

(a) Blood pump will stop.
(b) Arterial and venous clamps close.
(c) Dialysate fluid will bypass the dialyzer.

Why? To ensure no dialysate fluid passes through the rupture and into the patient's blood.

10.14.3 Interventions to be performed

(a) Check blood pump has stopped.
(b) Clamp both arterial and venous patients' access and blood circuit lines.
(c) Check fluid in dialysate tubes for signs of discolorations.
(d) Non-visible blood can be checked for by removing the out-flow dialysate tube and allowing some fluid from the dialyzer to moisten a urine multistix.
(e) True blood leak – dispose of the whole blood circuit. NEVER return any blood from the circuit to the patient.
(f) Check patients' observations: (blood pressure, pulse, temperature, respiratory rate, O_2 saturations)
(g) Re-prime a full dialysis circuit again and complete the patients prescribed dialysis.
(h) Ensure the dialysis machine completes a heat citric internal disinfection following dialysis

(i) Record as a dialysis incident as per local protocol.
(j) If the dialyzer problem is a manufacturing fault. Notify the manufacturer with the equipment batch and lot numbers and assess whether further stock needs withdrawing from use.

10.14.4 False blood leak alarm or negative to blood on multistix

(a) Check the blood circuit for air and remove by placing the circuit into re-circulation until alarm is clear and no visible air is seen.
(b) If the blood leak alarm cannot be reset – remove machine from service and request technical attention.
(c) If the dialysis machine has not been internally disinfected, document on the technician request repair form.

10.15 Standard conditions for blood sampling.

10.15.1 Pre-dialysis blood sampling procedure:

(a) For arteriovenous graft or fistula: obtain the blood from arterial needle before connecting the tube or flushing the needle, avoid dilution of the sample by saline and/or heparin.
(b) For central venous catheter. Using sterile technique withdraw any heparin/saline from the arterial port withdraw 10 ml of blood collect blood sample.

10.15.2 Post-dialysis blood sampling procedure:

As recirculation of dialyzed blood in the arterial line or rebound of urea can significantly influence the value of urea, the sampling technique must be performed in a standardized way leading to reproducible results.

In following the techniques explained below, the sample will be drawn after possible recirculation but before rebound of urea from peripheral compounds.

(a) Turn off dialysate flow or reduce to minimum, decrease ultrafiltration rate to 50 ml/h.
(b) Decrease blood flow to 50–100 ml/min for 15 s and proceed with slow pump.

Slow flow sampling technique

(a) Draw blood sample with pump running at 50–100 ml/min.
(b) Stop blood pump and complete disconnection procedure.

Stop pump sampling technique

(a) Stop the blood pump.
(b) Clamp arterial and venous blood lines; clamp arterial needle tubing.
(c) Sample blood either from arterial sampling port nearest to patient or from the arterial needle tubing after disconnection from the arterial blood line.
(d) Blood is returned to the patient, complete disconnection procedure.

Additional actions could be needed:

To consider when a patient is arranging a holiday

(a) Where is the nearest dialysis unit to where they wish to holiday and do they have space during the time they wish to visit?
(b) Will they need to pay and how much?
(c) Is the dialysis unit a recognized safe dialysis unit in a low risk area? If not, then ensure patient is aware of risks and consequence of such dialysis.
(d) Is the patient well enough to travel?
(e) Does the patient have good functioning access? Ideally and AVF or AVG.
(f) Has the patient been established on dialysis for a minimum of 6 months? Patients can travel before this time, but it may need further medical discussion.
(g) What specific tests are required to attend dialysis at the patient's chosen unit, and have they been completed along with all the relevant paperwork?
(h) Has the patient obtained travel insurance if travelling abroad?
(i) Has the transplant team been informed that the patient will be away during that period of time to allow suspension from the list?
(j) Have any other outpatient appointments or procedures been postponed if required?
(k) Ideally the patient should be vaccinated against hepatitis B.

Guideline 11

Nutrition for Patients on maintenance Hemodialysis

(11) Guideline on Nutrition for Patients on maintenance Hemodialysis
Nutritional status should be assessed at the start of hemodialysis.
Protein–energy malnutrition should be avoided in maintenance hemodialysis because of poor patient outcome.
In absence of malnutrition, nutritional status should be monitored every 6 months.

11.1 Diagnosis and monitoring of malnutrition

Protein–energy malnutrition and wasting are strong predictors of death among hemodialysis patients. There is not a single measurement that provides complete and unambiguous assessment of the nutritional status of hemodialysis patients.

Ideally, a nutritional marker should not only predict outcome, but it should also be an inexpensive, reproducible and easily performed test that is not affected by such factors as inflammation, gender, age and systemic diseases.

Dietitians: We recommend having Dietitians in hospitals, when available, to adjust and monitor the patients' diets and to consider the social and economics in each individual patient. They enable patients to adapt their regular diet to a diet that includes individual requirements.

All dietary information provided should be in writing and details should be recorded in the patient's care plan. It is essential to evaluate and modify individual dietary regimens after a further month or sooner as needed.

11.2 Nutritional status should be followed using the following assessment tools:

(a) Dietary interviews.
(b) Body weight.
(c) Serum albumin and serum cholesterol.
(d) The use of other technical investigations should be restricted to research purposes.

(A) Dietary interviews

(a) Stable and well-nourished Hemodialysis patients should be interviewed by a qualified dietitian every 6–12 months or every 3 months if they are over 50 years of age or on hemodialysis for more than 5 years.
(b) Malnourished hemodialysis patients should undergo at least a 24-h dietary recall more frequently until improved.

(B) Body weight

(a) Post dialysis body weight should be averaged over the month and percentage change in the average weight of the previous month, should be calculated.
(b) Percent inter-dialytic weight gain (IDWG) should be based on 'dry weight' (post dialysis)
(c) Significance of unplanned weight loss (Table 7)

Unplanned weight loss in past 3–6 months (% body weight)	Significance
>10% of body weight	Clinically significant
5–10% of body weight	More than normal intra-individual variation (potentially significant) – early indicator of risk of malnutrition increased
<5% of body weight	Within 'normal' intra-individual variation (small)

11.3 Recommended protein intake

The dietary protein intake in clinically stable chronic hemodialysis patients should be at least 1.1 g protein/kg ideal body weight/day.

(a) During routine hemodialysis, protein requirements do not appear to be sufficient for the following reasons. First, the dialysis treatment induces a loss of nutrients (glucose, amino acids, vitamins and trace elements) through the dialysis filter, which may even be more important today in response to the use of more porous membranes and/or more efficient techniques such as hemofiltration.
(b) Second, the dialysis procedure itself is a catabolic event responsible for protein catabolism (fragmentation of albumin, release of pro-inflammatory cytokines, role of heparin). For example, in response to the rapid decrease in plasma amino acid at the start of the hemodialysis session, muscle proteolysis occurs in order to maintain an adequate plasma and cellular amino acid concentration.
(c) This catabolic event may lead to muscle wasting over the long term. Feeding patients during the dialysis session through regular meals, special liquid feeding or parenteral administration has been shown to revert this catabolic state and should be used as frequently as possible.

11.4 Recommended energy intake

(a) The recommended energy intake in a clinically stable chronic hemodialysis patient should be 30–40 kcal/kg of ideal body weight (IBW/day), adjusted to age, gender and to the best estimate of physical activity level.
(b) Regular physical activity should be encouraged, and energy intake should be increased proportionally to the level of physical activity.

11.5 Minerals

Phosphate (phosphorus)

(a) A daily intake of 800–1000 mg phosphate is recommended.

(b) Dietary education improves phosphate control.
(c) Dietary phosphate control should not compromise protein intake.

Calcium

The total intake of elemental calcium should not exceed 2000 mg/day including calcium obtained from calcium-based phosphate binders.

Sodium and fluid

A daily intake of no more than 80–100 mmol (2000–2300 mg) sodium or 5–6 g (75 mg/kg BW) per day of sodium chloride is recommended. Interdialytic weight gain (IDWG) should not exceed 4–4.5% of dry body weight.

Potassium

In patients with pre-dialysis serum potassium greater than 6 mmol/l, a daily intake of potassium of 50–70 mmol (1950–2730 mg) or 1 mmol/kg IBW is recommended.

Zinc (Zn)

(a) A daily nutritional intake of 8–12 mg of elemental zinc (Zn) for women and 10–15 mg for men is recommended.
(b) Routine zinc supplementation is not recommended.
(c) A zinc supplementation of 50 mg Zn element per day for 3–6 months should be considered in hemodialysis patients with a chronic inadequate protein/energy intake and symptoms evoking zinc deficiency (impaired taste or smell, skin fragility, impotence, peripheral neuropathy).

11.6 Recommended dietary intake and supplements of vitamins and trace elements in adult hemodialysis patients (Table 8)

Vitamins	Daily recommendation
Thiamine hydrochloride (B1)	1.1–1.2 mg supplement
Riboflavin (B2)	1.1–1.3 mg supplement
Pyridoxine hydrochloride (B6)	10 mg supplement
Ascorbic acid (C)	75–90 mg supplement
Folic acid (B9)	1 mg supplement
Cobalamin (B12)	2.4 μg supplement
Niacin (B3, nicotinamide, nicotinic acid, PP)	14–16 mg supplement
Biotin (B8)	30 μg supplement
Pantothenic acid (B5)	5 mg supplement
Retinol (A)	700–900 μg intake (no supplement)
Alpha-tocopherol (E)	400–800 IU supplement[a]
Vitamin K	90–120 μg intake (no supplement)
Minerals and Trace elements	
Phosphorus	800–1000 mg intake
Calcium	2000 mg intake including calcium from phosphate binders
Sodium	2000–2300 mg intake, i.e. 5–6 g sodium chloride
Potassium	50–70 mmol intake (1950–2730 mg) or 1 mmol/kg[b]
Iron	8 mg (men) and 15 mg (women) intake [c]
Zinc	10–15 mg (men) and 8–12 mg (women) intake (no supplement)[d]
Selenium	55 μg intake (no supplement)

11.7 Ideal body weight estimation **BMI** BMI is calculated from the weight (kg) divided by the square of the height (m^2). BMI of maintenance dialysis patients should be maintained in the upper 50th percentile (BMI for men and women of at least ~23.6 and 24.0 kg/m^2)

(a) BMI less than 18.5° chronic protein–energy undernutrition probable.
(b) BMI 18.5–20.0° chronic protein–energy undernutrition possible.
(c) BMI more than 20.0° chronic protein–energy undernutrition unlikely.

Guideline 12

Patient-Reported Experiences of Dialysis Care

(12) Patient-Reported Experiences of Dialysis Care
12.1 Patient-reported outcome measures (PROMs), including patient-reported outcomes (PROs), are one of two primary sources of data about patients on hemodialysis.
12.2 Patients reported outcome measures will include quality of life, ease of therapies, geographical variations, transportation facilities, nutritional support and socioeconomic supportive funding for each individualized patient in the hemodialysis care centers.
12.3 Dialysis payers, administrators, providers, and staff deserve recognition for their considerable efforts and successes in incorporating PROMs into routine care and their continuous improving program to deliver the best management methods for patients on Dialysis.
12.4 A major challenge facing dialysis facilities around administering PROMs regards their financial and human resource costs. Therefore, we recommend that efforts be undertaken to explore reimbursement of costs and support for training.

Guideline 13

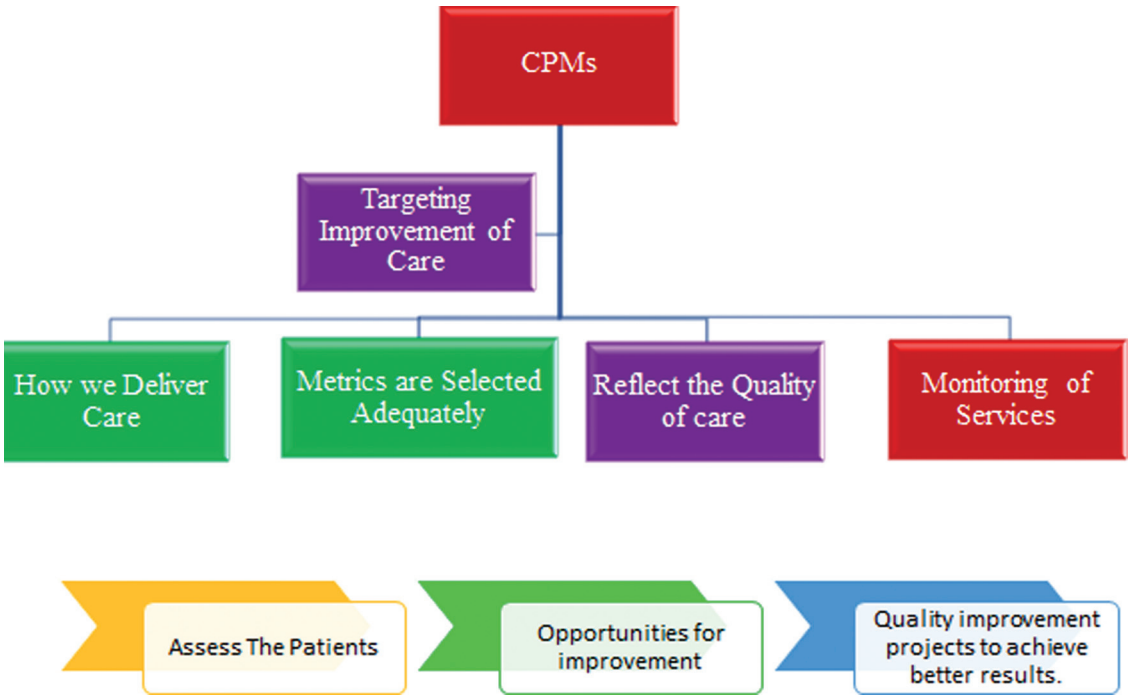
Clinical Performance Measurements CPMs

(13) Clinical Performance Measurements
CPGs and CPMs the Differences
13.1 Clinical Practice Guidelines (CPGs).
CPGs offer clinicians specific evidence-based care algorithms, designed to result in better patient outcomes.
13.2 Clinical Performance Measures (CPMs).
CPMs are clearly defined measures, specifying definitions of numerator and denominator to assess how well a population of patients adheres to a specific CPG.

(Fig 8 **Reporting and CPMS)**

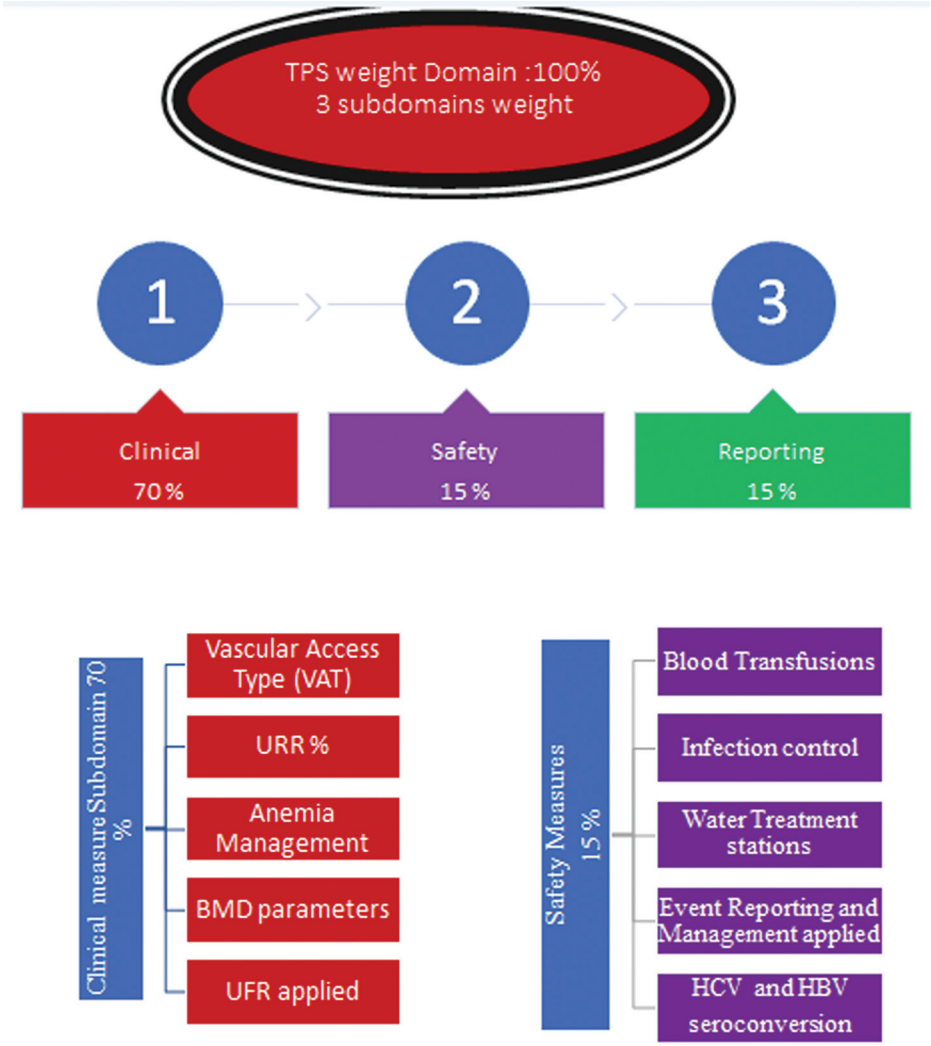
Total performance scores for hemodialysis centers

Figure 8

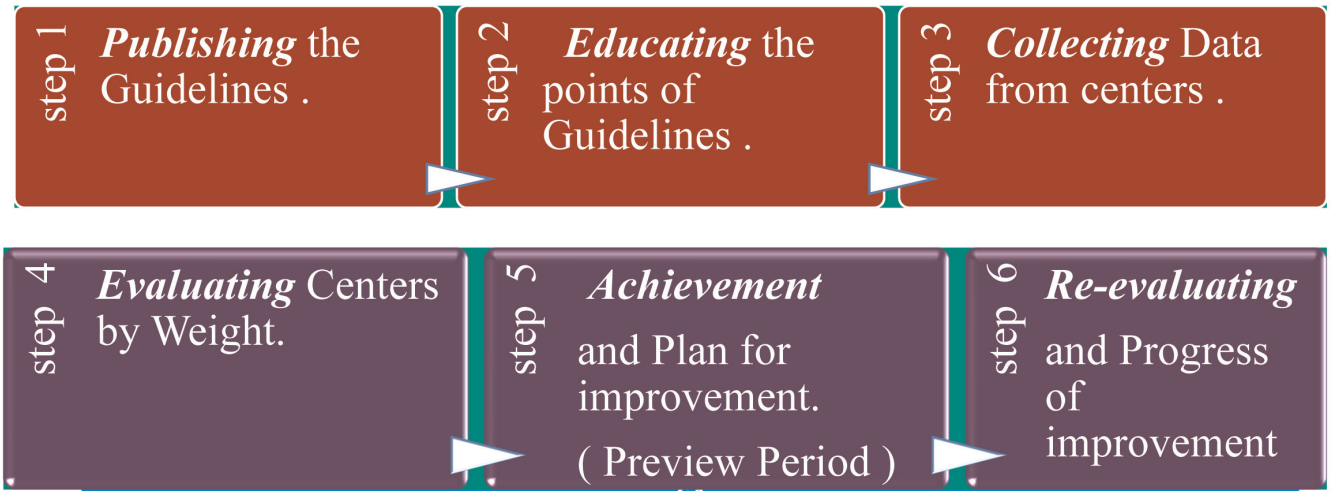


Clinical Performance Measurements (CPMs)

Figure 9



Total Performance Score in Hemodialysis centers (TPS)



Steps of Applied Guidelines

Center Weight by Domains and Subdomains

Centers will be classified by weight

1- Excellent centers > 70 % of total TPS .

2- Good Centers > 60 % of TPS .

3- Attention Centers < 50 % of TPS .

(1) **Achievement** – compares a unit's performance with dialysis units nationally.
(2) **Improvement** – compares a unit's performance to their previous year's performance.

Monitoring

The monitors of quality and access are needed to care for beneficiaries with ESRD. The monitoring program serves as an early-detection system to identify potential changes in ESRD service delivery, and alert of a need for further investigation or appropriate action.

Findings from the monitoring program help develop long-term evaluation studies to determine the cause(s) of observed changes and to drive continuous improvement.

(1) In-Center Hemodialysis Consumer Assessment of Healthcare Providers and Systems Survey: Percentage of patient responses to multiple survey measures to assess their dialysis providers, the quality of dialysis care they receive.
(2) Standardized Transfusion Ratio (STrR): Ratio of number of observed eligible red blood-cell transfusion events to the number of eligible transfusions that would be expected from a predictive model that accounts for patient characteristics within each facility (all adult dialysis patients).
(3) Kt/V or URR %: Percent of patients who achieved adequate Dialysis and **action plan** to achieve the adequate hemodialysis in group of patients who did not achieve adequate URR%.
(4) 4- Vascular Access types:
    (a) **Fistula:** Percentage of patient-months on hemodialysis during the last hemodialysis treatment of the month using an autogenous arteriovenous (AV) fistula with 2 needles
    (b) **Catheter:** Percentage of patient-months for patients on hemodialysis during the last hemodialysis treatment of the month with a catheter continuously for 90 days or longer prior to the last hemodialysis session including type of catheter either short term or long-term cuffed catheters.
(5) **Mineral Metabolism:** Number of patients with abnormal MBD finding on routine lab testing every 3 months: including serum calcium (>10.2 mg/dl), serum phosphorus (>5.5 mg/dl) and serum PTH (<100 and >800)
(6) **Anemia Management**: Number of patients who achieved the target hemoglobin level and the anemia management program applied to achieve the target including lab monitoring of anemia management indices as well ESA doses.

Performance Score Report and the Preview Period

What is the Performance Score Report?

(a) The Performance Score Report (PSR) is a document intended to inform a dialysis facility about its performance on quality measures during the performance Period, its Total Performance Score (TPS), how its score was calculated.
(b) Preview period is the time needed for each hemodialysis center to review the total performance score and the development of an optimizing program to achieve higher quality of care to hemodialysis patients.

Human Resources

Person-in-charge (PIC)

The person-in-charge (PIC) as defined in the Healthcare Facilities a person possessing such qualification, training and experience as may be prescribed and who shall be responsible for the management and control of the healthcare facility or service to which a license or registration relates. The PIC is the person held legally responsible in the Act to manage, control, maintain and operate the Hemodialysis unit.

Qualification:

The PIC of a hemodialysis center shall be a nephrologist.

Responsibilities:

Responsibilities of the nephrologist shall include:

(a) Advise on the facilities, equipment and staffing requirements of the center.

(b) Advise on policies and standards for hemodialysis treatment in conformity with the requirements of the regulations and/or any nationally accepted guidelines.
(c) Plan clinical management of the dialysis patients.
(d) Prescribing hemodialysis treatments. All Hemodialysis treatment shall be prescribed by a nephrologist.
(e) Review each individual patient. Such review shall be comprehensive and shall include but not limited to clinical examination, review of blood and other test results and medications.
(f) Recommend changes or modifications to treatment as deemed necessary from time to time in order to maintain the quality of care.

Registered Nurse and Medical Assistant

Qualifications

(a) A registered nurse/medical assistant shall have at least 6 months training and experience in hemodialysis and care of such patients under the supervision of registered nephrologists prior to performing hemodialysis treatment independently.
(b) The 6 months training and the certification program shall be as recognized by the Medical Director or nephrology consultants.

Responsibilities

Responsibilities of the trained registered nurse/medical assistant shall include:

(a) Performing hemodialysis treatment. Hemodialysis treatment and care shall be performed by a registered nurse or a registered medical assistant with training and experience in hemodialysis treatment and care.
(b) Monitoring of hemodialysis patients.
(c) Administration of medications.
(d) Supervising other nursing staff. Nursing staff other than a registered nurse may assist in the hemodialysis treatment and care of patients but may only perform such treatment and care under direct supervision of a trained registered nurse/ medical assistant.
(e) Care of dialysis equipment and systems.
(f) Education of hemodialysis patients and their families.

Dialysis Manager: It is desirable for the dialysis manager to have at least 2 years working experience in a dialysis center and is certified in Egyptian Society of Nephrology.

(1) A Hemodialysis Center should only be managed and controlled by only a nephrologist who had been registered in the ESNT.

Urologist and Non-nephrologist internal medicine should not be in charge of controlling, nor managing hemodialysis Centers.

A special educational program should be installed to guarantee the awareness and the Scientific approach to hemodialysis patients.

Staff-to-patient ratio

(a) An adequate number of staffs is required in the facilities to ensure care and treatments are performed safely and effectively.
(b) For every four dialysis patients, there shall be at least one nurse.
(c) A nephrologist as medical assistant with at least 6 months training in hemodialysis treatment and care in each shift.

Monitoring of hemodialysis patient

Refer to SOP: pre – during and post hemodialysis sessions.

The dialysis treatment shall be monitored closely, with particular attention to:

(a) Any intra-dialytic complications.
(b) Vital signs during dialysis: blood pressure, pulse and temperature.
(c) Vascular access.

Records of dialysis treatments

Each dialysis treatment shall be recorded.

Long-term monitoring of dialysis patients

(1) Blood investigations shall be performed at regular intervals or more frequently if necessary. The minimum frequency is monthly based for Hb and URR% and every 3 months for viral markers and biomarkers of CKD-MBD.
(2) **Dialysis Adequacy**
  (a) Dialysis adequacy shall be monitored at least monthly.
  (b) This can be calculated using Kt/V or Urea Reduction Ratio (URR).

Guideline 14

Infection control measures

(14) Infection control measures
14.1 Measures to prevent transmission of infection.
14.2 Infection Control Training and Education.
14.3 Checklist: Dialysis Station Routine Disinfection.
14.4 Infection control practices (hygienic precautions).
14.5 Hygienic precautions for Hemodialysis (dialysis machines).
14.6 Dialysis Water Quality and Dialysate infection control.
14.7 Guidelines for the Prevention of Intravascular Catheter-Related Infection.

14.1 Measures to prevent transmission of infection

Infection Control precautions for all patients and staff working in hemodialysis unit shall ensure implementation of and adherence to strict infection control procedures designed to prevent cross-infection.

14.2 Infection Control Training and Education

Training and education are recommended for both staff members and patients (or their family and care givers).

14.3 Checklist: Dialysis Station Routine Disinfection

(a) This list can be used if there is no visible soil on surfaces at the dialysis station.
(b) If visible blood or other soil is present, surfaces must be cleaned prior to disinfection.

Part A: Before beginning routine disinfection of the dialysis station

(a) Disconnect and takedown used blood tubing and dialyzer from the dialysis machine.
(b) Discard tubing and dialyzers in a leak-proof container.
(c) Check that there is no visible soil or blood on surfaces.
(d) Ensure that the priming bucket has been emptied.
(e) Ensure that the patient has left the dialysis station.
(f) Discard all single-use supplies. Move any reusable supplies to an area where they will be cleaned and disinfected before being stored or returned to a dialysis station.
(g) Remove gloves and perform hand hygiene.

Part B: Routine disinfection of the dialysis station – after patient has left station

(a) Wear clean gloves. Apply disinfectant to all surfaces in the dialysis station using a wiping motion (with friction).
(b) Ensure surfaces are visibly wet with disinfectant.
(c) Allow surfaces to air-dry.
(d) Keep used or potentially contaminated items away from the disinfected surfaces.
(e) Remove gloves and perform hand hygiene.
(f) Do not bring patients or clean supplies to station until these steps have been completed.

14.4 Infection control practices ('hygienic precautions')

(a) Proper hand hygiene and glove changes, especially between patient contacts, before invasive procedures, and after contact with blood and potentially blood-contaminated surfaces/supplies.
(b) Proper injectable medication preparation practices following aseptic techniques and in an appropriate clean area.
(c) Proper injectable medication administration practice thorough cleaning and disinfection of surfaces at the dialysis station, especially high-touch surfaces.
(d) Adequate separation of clean supplies from contaminated materials and equipment.

14.5 Hygienic precautions for Hemodialysis (dialysis machines)

Definitions

The '**transducer protector**' is a filter (normally a hydrophobic 0.2-mm filter) that is fitted between the pressure-monitoring line of the extracorporeal circuit and the pressure-monitoring port of the dialysis machine.

The filter allows air to pass freely to the pressure transducer that gives the reading displayed by the machine, but it resists the passage of fluid. This protects the patient from microbiologic contamination (as the pressure monitoring system is not disinfected) and the machine from ingress of blood or dialysate. An external transducer protector is normally fitted to each pressure-monitoring line in the blood circuit. A back-up filter is located inside the machine. Changing the internal filter is a technical job.

A '**single-pass machine**' is a machine that pumps the dialysate through the dialyzer and then to waste. In general, such machines do not allow fluid to flow

between the drain pathway and the fresh pathway except during disinfection. 'Recirculating' machines produce batches of fluid that can be passed through the dialyzer several times.

(a) Transducer protectors, external transducer protectors should be fitted to the pressure lines of the extracorporeal circuit.
(b) Before commencing dialysis, staff should ensure that the connection between the transducer protectors and the pressure-monitoring ports is tight, as leaks can lead to wetting of the filter.
(c) Transducer protectors should be replaced if the filter become wet, as the pressure reading may be affected.
(d) Using a syringe to clear the flooded line may damage the filter and increase the possibility of blood passing into the dialysis machine.
(e) If wetting of the filter occurs after the patient has been connected, the line should be inspected carefully to see if any blood has passed through the filter.
(f) If any fluid is visible on the machine side, the machine should be taken out of service at the end of the session so that the internal filter can be changed and the housing disinfected.

External cleaning:

(a) After each session, the exterior of the dialysis machine and all surfaces in the dialysis treatment station should be cleaned with a low-level disinfectant if not visibly contaminated.
(b) Pay particular attention to high-touch surfaces that are likely to come into contact with the patient (e.g. arm rests or blood pressure cuff) or staff members' hands (e.g. machine control panel).
(c) Disinfection of external machine surfaces should not commence until the patient has left the dialysis treatment station.

A complete (unit-wide) patient-free interval between shifts might facilitate more thorough cleaning and disinfection of the unit.

(a) If a blood spillage has occurred, the exterior should be disinfected with a commercially available tuberculocidal germicide or a solution containing at least 500 ppm hypochlorite (a 1: 100 dilution of 5% household bleach) if this is not detrimental to the surface of dialysis machines.
(b) Advice on suitable disinfectants, and the concentration and contact time required, should be provided by the manufacturer.
(c) If blood or fluid is thought to have seeped into inaccessible parts of the dialysis machine (e.g. between modules or behind the blood pump), the machine should be taken out of service until it can be dismantled and disinfected.

Disinfection of the internal fluid pathways

(a) Facilities may still need to disinfect the dialysate-to-dialyzer (Hansen) connectors before the next patient.
(b) Machines should always be put through an appropriate disinfection procedure between patients that is usually heat disinfection and hot rinsing.

14.6 Dialysis Water Quality and Dialysate infection control

Adhere to current AAMI standards for quality assurance performance of devices and equipment used to treat, store, and distribute water in Hemodialysis centers (both acute and maintenance [chronic] settings) and for the preparation of concentrates and dialysate (AAMI: ANSI/AAMI RD5:1992, ANSI/AAMI RD 47:1993) and for the Egyptian MOH standard.

(a) Perform bacteriologic assays of water and dialysis fluids at least once a month and during outbreaks using standard quantitative methods (AAMI: ANSI/AAMI RD 62:2001) and for the Egyptian MOH standard.
(b) Assay for heterotrophic, mesophilic bacteria (e.g. *Pseudomonas* spp).
(c) Do not use nutrient-rich media (e.g. blood agar or chocolate agar).
(d) Disinfect water distribution systems in dialysis settings on a regular schedule. Monthly disinfection is recommended.
(e) Whenever practical, design and engineer water systems in dialysis settings to avoid incorporating joints, dead-end pipes, and unused branches and taps that can harbor bacteria.
(f) When storage tanks are used in dialysis systems, they should be routinely drained and disinfected and that should be followed by testing for any residual before use in dialysate preparation.

14.7 Guidelines for the Prevention of Intravascular Catheter-Related Infection

Education, Training and Staffing

(a) Educate healthcare personnel regarding the indications for intravascular catheter use, proper

procedures for the insertion and maintenance of intravascular catheters, and appropriate infection control measures to prevent intravascular catheter-related infections.
(b) Periodically assess knowledge of and adherence to guidelines for all personnel involved in the insertion and maintenance of intravascular catheters.
(c) Designate only trained personnel who demonstrate competence for the insertion and maintenance of peripheral and central intravascular catheters.

Hand Hygiene and Aseptic Technique

(a) Perform hand hygiene procedures, either by washing hands with conventional soap and water or with alcohol-based hand rubs (ABHR). Hand hygiene should be performed before and after palpating catheter insertion sites as well as before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter. Palpation of the insertion site should not be performed after the application of antiseptic, unless aseptic technique is maintained.
(b) Maintain aseptic technique for the insertion and care of intravascular catheters.
(c) Sterile gloves should be worn for the insertion of arterial, central, and midline catheters.
(d) Use new sterile gloves before handling the new catheter when guide wire exchanges are performed.
(e) Wear either clean or sterile gloves when changing the dressing on intravascular catheters.

Skin Preparation

(a) Prepare clean skin with an antiseptic (70% alcohol, tincture of iodine, or alcoholic chlorhexidine gluconate solution) before peripheral venous catheter insertion.
(b) Prepare clean skin with a more than 0.5% chlorhexidine preparation with alcohol before central venous catheter and peripheral arterial catheter insertion and during dressing changes. If there is a contraindication to chlorhexidine, tincture of iodine, an iodophor, or 70% alcohol can be used as alternatives.
(c) No comparison has been made between using chlorhexidine preparations with alcohol and povidone–iodine in alcohol to prepare clean skin.

Catheter Site Dressing Regimens

(a) Use either sterile gauze or sterile, transparent, semipermeable dressing to cover the catheter.
(b) If the patient is diaphoretic or if the site is bleeding or oozing, use a gauze dressing until this is resolved.
(c) Replace catheter site dressing if the dressing becomes damp, loosened, or visibly soiled.
(d) Do not use topical antibiotic ointment or creams on insertion sites, **except for dialysis catheters**, because of their potential to promote fungal infections and antimicrobial resistance.
(e) Do not submerge the catheter or catheter site in water. Showering should be permitted if precautions can be taken to reduce the likelihood of introducing organisms into the catheter (e.g. if the catheter and connecting device are protected with an impermeable cover during the shower).
(f) Replace dressings used on short-term CVC sites every 2 days for gauze dressings.
(g) Replace dressings used on short-term CVC sites at least every 7 days for transparent dressings, except in those pediatric patients in which the risk for dislodging the catheter may outweigh the benefit of changing the dressing.
(h) Replace transparent dressings used on tunneled or implanted CVC sites no more than once per week (unless the dressing is soiled or loose), until the insertion site has healed.
(i) No recommendation can be made regarding the necessity for any dressing on well-healed exit sites of long-term cuffed and tunneled CVCs.
(j) Ensure that catheter site care is compatible with the catheter material.

Systemic Antibiotic Prophylaxis

Do not administer systemic antimicrobial prophylaxis routinely before insertion or during use of an intravascular catheter to prevent catheter colonization or CRBSI.

Rational for HD Strategies

Rationale for Initiation of Hemodialysis:

The balance among the benefits, risks, and disadvantages of initiating or not initiating dialysis should be evaluated, considering education received and preferences expressed by the patients and/or their caregivers.

Symptoms of uremia are nonspecific, and attempts should be made to evaluate for other, sometimes reversible, causes of symptoms. Moreover, uremic symptoms can be subtle, and patients may adapt to lower levels of functioning or well-being without clearly expressing symptoms.

The decision to initiate RRT should not be based on estimated GFR (eGFR) level alone.

Clinical Settings Affecting Creatinine Generation (Table 9):

Clinical settings affecting creatinine generation	
Setting	Effect on serum creatinine
Demographic characteristics	
Older age	Decreased
Female sex	Decreased
African American	Increased
Hispanic	Decreased
Asian	Decreased
Clinical characteristics	
Muscular habitus	Increased
Rhabdomyolysis	Increased
Loss of muscle (amputation, neuromuscular diseases, cachexia)	Decreased
Cirrhosis/advanced liver disease	Decreased
Protein-energy wasting/ inflammation	Decreased
Dietary characteristics	
Vegetarian/vegan diet	Decreased
High meat diet	Increased

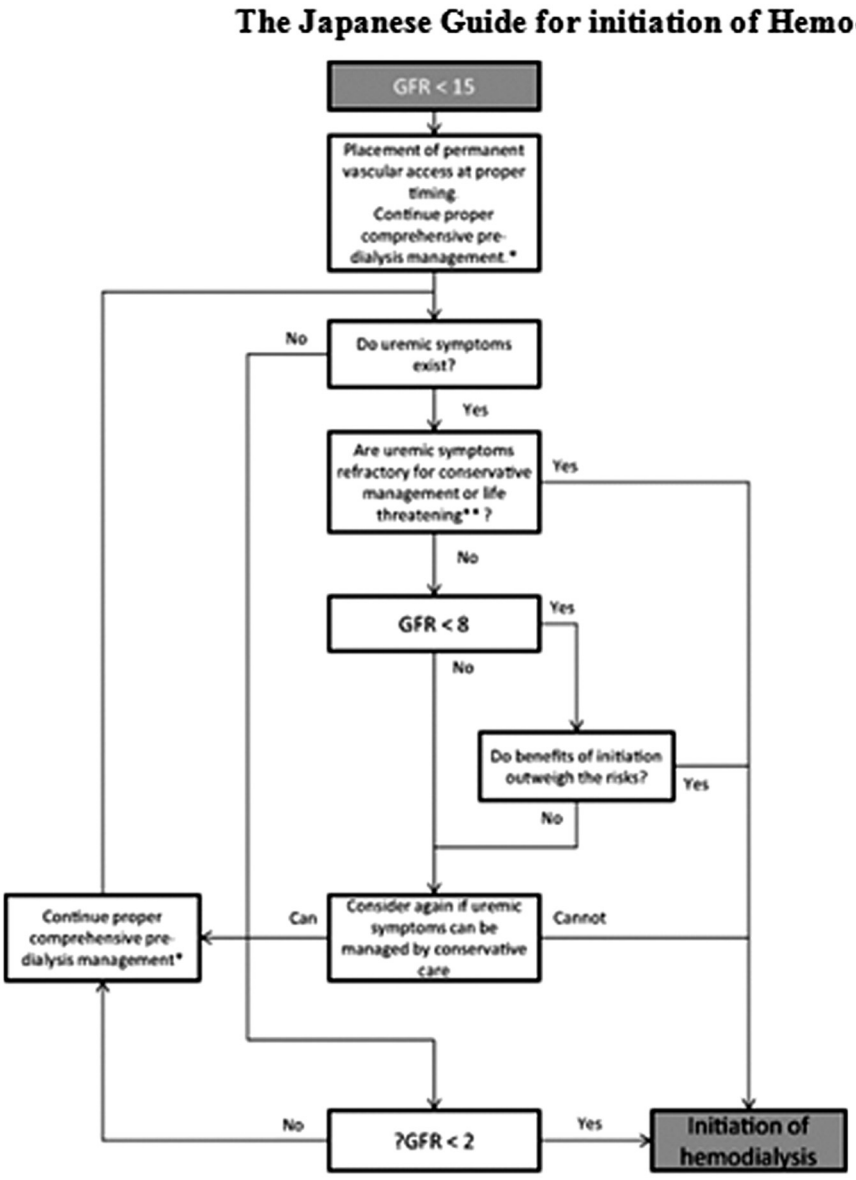
(*Continued*)

(*Continued*)

The Japanese Guide for initiation of Hemodialysis

(Fig 10 **Approach for initiation of Hemodialysis)**

Figure 10



Approach for initiation of hemodialysis.

Rationale for Individualizing Dialysate in Patients on Hemodialysis (Table 10)

Adverse reactions due to an excessively LOW concentration		Adverse reactions due to an excessively HIGH concentration
– Intradialytic cardiovascular instability	Na^+	– Refractory hypertension
– Disequilibrium symptoms (fatigue, muscle cramps, headache, etc.)		– Intradialytic hypertension
		– Increased thirst sense
		– Pulmonary edema
– Arrhythmogenic effect amplified by a rapid correction of metabolic acidosis, low dialysate calcium concentration, high ultrafiltration rate, abrupt kalemia decrease	K^+	– Risk of insufficient potassium removal with secondary hyperkalemia in the interdialytic period
		– Increased mortality
– Hypotension and cardiac arrhythmias during Hemodialysis and long-term risk of secondary hyperparathyroidism	Ca^{++}	– Long-term risk of vascular and valvular calcifications
– Increased risk of sudden cardiac arrest		– Significantly higher risk of cardiovascular and sudden death in patients who are taking a calcium-based phosphate binder
– Increased circulating parathyroid hormone levels (PTH) in the presence of adynamic bone disease and low serum PTH levels		Risk of over suppression of parathyroid hormone and adynamic bone disease, with high plasma [Ca] and soft-tissue calcifications
– Risk of excessive bone mineral loss in patients with long daily or nocturnal Hemodialysis sessions		
– Leg cramps	Mg^{++}	– Signs and symptoms of hypermagnesemia (hyporeflexia, weakness up to paralysis that can involve the diaphragm, bradycardia, hypotension, cardiac arrest, inhibition of parathyroid hormone secretion with secondary hypocalcemia)
– Significant drop in mean arterial pressure in the association of dialysate calcium concentration of 1.25 mmol/l and magnesium concentration of 0.25 mmol/l		
– Acidosis with secondary abnormal protein metabolism and malnutrition	HCO_3^-	– Increased calcium binding to proteins, reduction of ionized calcium, and impaired cardiac muscle contraction and arterial pressure preservation
– Osteodystrophy		– Hypoxemia, with further impaired cardiac function
		– Increased potassium removal
		– Accelerated tissue calcium phosphate precipitation
– Risk of hypoglycemia	Glucose	– Impaired triglyceride metabolism
– Greater loss of amino acids in the dialysate		
– Higher potassium removal secondary to alkalosis		– Risk of pro-inflammatory stimulus secondary to hyperglycemia

All dialysate should be individualized and symptoms and signs of low or high dialysate solute according to the table below.

Possible adverse effects secondary to the prescription of the wrong hemodialysate; the table shows, for each component of the hemodialysate, the major possible short-term and long-term adverse reactions secondary to an excessively low (left column) or to an excessively high dialysate concentration (right column).

Rationale for Dialysate Calcium and Magnesium:

Dialysate Calcium

Interpretation of the serum or plasma calcium concentration requires an interpretation of the units of measurement, as well as an understanding of whether total or ionized calcium is being measured. The calcium concentration in serum or plasma can be expressed as mg/dl, mmol/l, or mEq/l.

Typical normal ranges for total and ionized calcium (Table 11)

	Total calcium	Ionized calcium
mg/dl	8.8–10.2	4.4–5.4
mmol/l	2.2–2.6	1.1–1.35
mEq/l	4.4–5.2	2.2–2.7

(1) The KDIGO guideline states that: in patients with CKD stage 5D, we suggest using a dialysate calcium concentration of 1.25–1.50 mmol/l (2.5–3.0 mEq/l).

(2) Concern for hypercalcemia arises from the intuitive but largely unproven hypothesis that positive net calcium balance predisposes toward vascular calcification in kidney disease, and that this in turn contributes to the burden of cardiovascular disease in dialysis patients. The vascular calcification hypothesis has led to increasing use of phosphate binders that do not contain calcium, like sevelamer and lanthanum, and expanded use of calcimimetics, such as cinacalcet.
(3) If dialysate calcium concentrations are below 2.5 mEq/l, which likely results in negative calcium balance with resultant hypocalcemia, this stimulates parathyroid hormone, which can promote vascular calcification by mobilizing skeletal calcium into the blood stream and is precisely the opposite of the intended effect. Importantly though, lower dialysate calcium may improve bone turnover in patients with adynamic bone disease.
(4) Lower dialysate calcium may result in additional risks. Hypocalcemia has been associated with QTc interval prolongation, myocardial ischemia and stunning, and hypotension due to decreased vascular resistance and lower cardiac output.

Dialysate Magnesium

Magnesium is a divalent ion with a normal plasma concentration between 0.65 and 1.0 mmol/l (1.3–2.0 mEq/l; 1.6–2.4 mg/dl).

(1) Very little attention has been given to factors affecting the selection of dialysate magnesium concentrations, which are often determined by the facility and the dialysate manufacturer rather than by individual prescription.
(2) Magnesium is a cofactor in more than 300 human enzymatic reactions, and the secondary consequences of abnormal magnesium levels remain to be defined.
(3) Hypomagnesemia is associated with cardiovascular mortality in the general population, as well as CKD patients, including those treated with dialysis.
(4) Magnesium levels are not regulated by any known hormone, so a reduction in dialysate magnesium levels from early values of 1.5 mEq/l to current levels of 0.5–1.0 mEq/l would be expected to result in net removal of magnesium from the extracellular space. Although the dialyzable fraction is less than 1% of total body magnesium, as magnesium primarily is located within cells, the cumulative effects of small magnesium losses over time may be magnified by a shift toward lower total dietary uptake of magnesium.
(5) **The evidence suggests risk of ongoing magnesium depletion** when conventional dialysates are used, especially in patients with poor nutrition and those taking proton-pump inhibitors. Clinicians should be aware of this possibility and consider avoiding low magnesium dialysates, monitoring for hypomagnesemia, and treating with adjustments in dialysate or oral supplements.
(6) **The best survival** observed at serum magnesium levels more than or equal to 1.25 mmol/l (2.5 mEq/l).
(7) **The pendulum has swung back in recent years:** current manufacturers commonly provide dialysate products with final magnesium content of 0.5 mmol/l (1.0 mEq/l).
(8) Given the high prevalence of hypomagnesemia, risk associations with mortality, and potentiating effect on potassium shifts, we suggest standard prescription of higher-magnesium dialysate levels of 0.5 mmol/l (1.0 mEq/l), particularly among patients who are hypokalemic and patients subject to large serum-dialysate potassium gradients

Rationale for Hemodialysis Membranes and Fluxes:

High-Flux membranes employed in convective and mixed diffusion/convection therapies achieve the maximal removal of small- and middle-molecular toxic solutes and, at least in the case of β2-microglobulin, establish lower long-term concentrations. Prolonged use of such membranes in high efficiency dialysis techniques helps prevent some long-term complications of the uremic status, such as dialysis-related amyloidosis.

Solute removal in hemofiltration/hemodiafiltration

Middle molecular weight solute removal obtained with highly permeable and biocompatible membranes employed in convective and mixed diffusion/convection strategies is definitely higher than that attainable by 'internal filtration' in High-Flux HD. Indeed, several randomized trials conducted in the last years have confirmed that hemofiltration (HF) and hemodiafiltration (HDF) achieve a significant enhancement and widening of the molecular spectrum of the removed uremic compounds compared with both low-flux and High-Flux HD. This has been demonstrated for small molecular solutes as urea, creatinine and phosphate, for middle molecular compounds as β2-m, cystatin C, leptin,

retinol-binding protein and for protein-bound solutes as p-cresol and AGEs. Moreover, enhanced removal by convection has been proven in controlled experimental settings for asymmetric dimethyl-arginine (ADMA) complement fractions such as factor D, and with a contribution of absorption onto the membrane, for pro-inflammatory cytokines such as TNF-α and interleukins 1, 6, and 8.

Increasing evidence, provided by long-term prospective studies, demonstrates that increased removal obtained by high rates of fluid exchange with HDF and HF results in lower levels of small- and medium-large sized solutes. A prospective randomized study comparing High-Flux HD with HDF at a relatively low infusion volume (8–12 l/session) found similar basal β2-m levels over a period of 24 months, but significant differences in basal β2-m levels emerged from a long-term prospective study in which a mean filtration volume of 21 l was applied. Higher removal in HDF/HD versus High-Flux HD was demonstrated in prospective trials for urea, phosphate, β2-m, factor D, homocysteine and AGEs.

The maximum safe filtration rate is determined by the infusion mode, the blood flow rate, hydraulic permeability and surface area of the dialyzer membrane and the patient's characteristics (hematocrit and total protein concentration, coagulability status). These factors, to a different extent, contribute to the establishment of the pressure regimen necessary for the planned filtration. Presently, a feedback control system preventing excessive trans-membrane pressure increase beyond a safe maximum value (i.e. 300 mmHg) by modulating infusion and filtration rate is the most advanced tool to avoid technical and clinical drawbacks of an excessive filtration. In the absence of such equipment, the following general rules can be applied. Post dilution; the filtration rate should be limited to ~40% of plasma water flow rate, corresponding to ~25% of blood flow rate. Pre dilution; the infusion rate should not exceed the plasma water flow rate, to avoid loss of efficiency as a consequence of the excessive dilution of solute concentration. Ultrapure dialysate is mandatory for on-line production of the infusion fluid. The infusion fluid must be sampled periodically to ensure that it is free of endotoxin and meets the standards of microbial purity.

Clinical results of increasing flux

The above middle-molecular compounds have a pathogenic role or are markers of the most frequent long-term complications and causes of death in HD patients such as dialysis-related amyloidosis, cardio-vascular disease, secondary hyperparathyroidism, inflammation and malnutrition. Reduction of the accumulation and lower long-term levels of these compounds may prevent or delay the appearance of such complications. Significant reductions in the incidence of carpal tunnel syndrome and signs of dialysis-related amyloidosis have been reported. The increased ability of High-Flux membranes to remove phosphate may translate into lower serum phosphate level in the long term, as shown by some prospective studies. Control of hyperphosphatemia has been associated with improved patient survival in a large cohort of patients from two special studies of the USRDS. A recent randomized study comparing High-Flux and low-flux Polysulfide membranes at similar efficiency (Kt/V) suggested that High-Flux dialysis was more effective in terms of controlling renal anemia and reducing the need of erythropoietin therapy. These beneficial effects of High-Flux dialysis have been attributed to the improved clearance of middle- and high-molecular weight toxins. Similar findings have been described in other prospective and observational studies performed in patients on convective and mixed therapies compared with low-flux Hemodialysis. However, in patients who are, adequately dialyzed, and not iron- and/or vitamin-depleted, this favorable effect was not confirmed in several trials comparing low-flux HD with high flux HD or HDF.

Outcome in High-Flux HD and HDF/HF

In the last decade, several observational studies from large databases have reported a reduced death risk in patients undergoing Hemodialysis with High-Flux membranes. In some studies, such an effect has been associated with the increased removal of middle-molecular uremic toxins promoted by these membranes independently from the effects related to their high biocompatibility.

Rationale for Frequency of adequacy testing

Numerous studies have shown that low dialysis dose is associated with poor outcome Inadequate dialysis may be difficult to detect clinically or by routine biochemical tests. Faults in the system for delivering dialysis (which includes the fistula, dialysis machine, prescription, schedule and dialyzer) may be unpredictable and results in inadequate dialysis. To prevent adverse effects on the patient due to inadequate dialysis,

adequacy measurements are customarily taken monthly along with routine biochemical tests.

Method of adequacy testing, need for a reference method

Various methods have been proposed and are in use for calculating dialysis dose. Dose calculated using many of these methods have been shown to relate to outcome. All methods are based on indirect measurement of mass of urea (or a urea surrogate) removed from the patient over a dialysis session. Differences between methods relate to the extent to which ultrafiltration, urea generation, residual renal function, urea distribution volume and the post-dialysis rebound are considered.

As long as a dialysis facility uses a validated method for calculating dose and applies it consistently and properly, it does not matter which method is used for routine surveillance of the patient. The need for a reference method arises when an external standard is applied (such as minimum recommended dose) and when results are to be exported to a registry or used in research. In this case, the relationship between any method in use for calculating dose and the reference method must be known.

The most common method for calculating dose cited in publications is the formal variable-volume, single-pool urea kinetic model of Gotch, returning the single-pool Kt/V (spKt/V). This has become the de-facto reference method for Hemodialysis dose. The Gotch method requires input of pre- and post-dialysis weight, height, sex, age, dialyzer type, blood flow, dialysate flow, dialysis time, pre- and post-dialysis urea or BUN. The spKt/V returned by the reference method takes urea generation, ultrafiltration and urea distribution volume into account. The spKt/V can be calculated independently from both the dialysis prescription and blood urea measurements to validate the result.

When dialysis is applied intermittently as in Hemodialysis, there is always a significant disequilibrium between body water compartments. This results in a significant post-dialysis urea rebound which takes 30–40 min to complete. Unless the post-dialysis sample is taken after the rebound is complete, the Gotch method will significantly overestimate dialysis dose. This overestimation is relatively greater in shorter dialysis, about 25% in a 2 h dialysis compared with 10% in a 5 h dialysis. It has been shown that the Gotch method using an immediate post-dialysis blood sample can easily be corrected for these disequilibrium effects by applying an additional term with input of dialysis session duration (td). This equilibrated Kt/V (eKt/V) taking the post-dialysis rebound into account, has been validated. Since td is already required by the Gotch method and since the Gotch method already requires a computer to calculate, rebound correction, returning eKt/V adds no additional cost or logistical complexity.

Trouble shooting and validation

A major advantage of Kt/V is that it can be independently calculated from dialysis session time (t), an estimation of V using body weight and an estimation of K using blood flow, dialysate flow and dialyzer urea clearance coefficient. Any discrepancy between the 'prescribed' Kt/V calculated in this way and the 'delivered' Kt/V calculated using pre- and post-dialysis blood samples can yield valuable diagnostic information. For example, incorrect sampling technique may cause the 'delivered' Kt/V to be much higher than 'prescribed' Kt/V. Access recirculation may result in the 'delivered' Kt/V being less than 'prescribed' Kt/V.

Other methods used for calculating dialysis dose may be easier to use, with fewer input variables, yet return a result which is a reasonable approximation of the Gotch method. The simplest of these is the urea reduction ratio (URR) which is the fall in blood urea concentration over the dialysis session divided by the pre-dialysis urea. URR can be expressed as Kt/V by the logarithmic transformation;

$$\mathrm{Kt/V} = \ln\left(\frac{1}{1-\mathrm{URR}}\right)$$

This simple method for calculating Kt/V does not take ultrafiltration, urea generation or the post-dialysis rebound into account. For a 4 h dialysis with 2 l of ultrafiltration, these effects approximately cancel out and the result is very close to eKt/V calculated by the reference method. For dialysis sessions shorter than 4 h or with less than 2 l ultrafiltration, the URR method will significantly overestimate eKt/V. The URR method may be used as an approximation for practical purposes but should not substitute for monthly measurement of eKt/V by the reference method.

Online clearance methods are increasingly used to calculate dialysis dose without blood samples. The equipment is built-in to the dialysis machine and calculates dose from measurements of dialysate conductivity. Online clearance calculates a precise

value for Kt. It estimates Kt/V using an estimation of V from inputs of patient weight, height, age and sex. These estimations of V are known to be an overestimate, causing Kt/V to be underestimated. Kt/V calculated by online clearance is not necessarily automatically corrected for rebound, though this could easily be done by the equipment. Online clearance is not currently validated for hemodiafiltration or hemofiltration.

As long as the difference between Kt/V calculated by the online clearance and the reference method is considered, online clearance is an acceptable method for calculating Hemodialysis on a treatment-by-treatment basis. Online clearance should not substitute for monthly measurements using the reference method.

Rationale to optimize the HD dose by testing Recirculation

Definition of Access Recirculation

Normally the rate of blood flow through an A-V access and especially AV grafts is about 1 liter per minute. During HD the blood pump of HD machine, which normally pumps out blood from the access into the dialyzer, usually is set to take a flow of 300–500 ml/min. Because the demand of blood pump is less than the blood flow of A-V access, usually all of the blood coming into the blood pump is coming from the arterial side of access. Now, in some instances for example in a failing A-V access, flow through the access can decrease markedly to less than the rate of blood pump of HD machine, therefore some of the dialyzed blood leaving the dialyzer through the venous needle reenters the dialyzer through the arterial side to support the extracorporeal blood flow rate set by the blood pump. This phenomenon is named access recirculation (AR).

Clinical Significance of Access Recirculation

Access recirculation is diagnosed when the blood solute concentration in arterial line is lower than that of systemic circulation, indicating that there has been mixing of dialyzed blood with unanalyzed blood entering the dialyzer. In this phenomenon, by mixing already dialyzed with unanalyzed blood, the urea concentration in the blood entering the dialyzer may be reduced by 10–40% or more. Therefore, when AR occurred, solute concentration gradients across the dialysis membrane and as a result the rate of removal of solutes are reduced. It is also recommended that the presence of high degrees of access recirculation should be suspected when there is an inadequate reduction in the blood urea nitrogen (BUN).

The Measurement of Access Recirculation

There are two most common techniques for accurate assessment of access recirculation: Urea (or chemical) and non-urea-based method by ultrasound dilution technique (or dilutional-based method).

In ultrasound dilution-based method, two reusable clip ultrasound sensors are attached to the venous and arterial blood line, which are linked to a computer and access blood flow is checked. Then dialyzer blood lines are reversed; the ultrafiltration is turned off, and at a known flow rate, 10 ml of isotonic saline is quickly injected into the venous line to dilute the blood. The velocity of the blood dilution as it passes through the blood lines is measured by ultrasonography.

In urea-based method, the degree of access recirculation is measured by comparing the systemic and dialyzer inlet blood urea concentration (BUC) from the following formula:

$$\text{Percent recirculation} = ([P - A] \div [P - V]) \times 100$$

In the above formula P, A, and V refer to the systemic urea concentrations in the peripheral blood, blood entering the arterial line, and post-dialyzer venous circuit, respectively.

If there were no recirculation, urea concentration in blood entering the dialyzer (A) would be equal to the systemic urea concentration (P), and the above formula would have a value of zero. On the other hand, access recirculation exists whenever the BUC in the blood entering the arterial line is lower than that in the peripheral sample, indicating dialyzed blood reenter to the arterial line rather than returning to the systemic circulation.

The Causes of Access Recirculation

(1) The presence of high-grade venous stenosis.
(2) Inadequate arterial blood flow rate.
(3) Improper needle placement by HD staff during HD.

Rationale For IDH:

Two types of hypotensive episodes have been distinguished during dialysis (bradycardic and

tachycardic). Most frequently, episodes of IDH are preceded by a gradual decline in BP and increase in heart rate. Alternatively, IDH episodes may occur suddenly and be associated with a bradycardic response (Bezold Jarish reflex), which is believed to originate from activation of left ventricular mechanoreceptors due to severe ventricular underfilling. In the tachycardic type of IDH, it is conceivable that IDH may be prevented by adjusting ultrafiltration, although no studies have been performed into this subject.

It has been shown that the presence of cardiac disease, leading to systolic or diastolic dysfunction of the heart increases the risk for IDH. An increase in myocardial contractility is a physiological response to a decline in blood volume, which can be impaired by systolic dysfunction of the heart. During comparable ultrafiltration rates, the decline in BP was larger in patients with systolic dysfunction compared with patients with normal systolic function. Diastolic dysfunction increases the sensitivity of the patient for changes in preload, i.e. both for underhydration and overhydration. In patients prone to IDH, diastolic filling was found to be impaired. A potential problem with the assessment of diastolic dysfunction in Hemodialysis patients is the fact that indices which are used to assess diastolic dysfunction are preload dependent. Diastolic dysfunction is often related to the presence of left ventricular hypertrophy but may also be due to myocardial ischemia or fibrosis. The presence of supraventricular arrhythmias may also compromise ventricular filling, which may be especially evident in patients with systolic or diastolic dysfunction. Echocardiography is a simple and non-invasive tool. Based on the echocardiographic findings and the clinical assessment of the patient, further cardiologic evaluation of the patient may be warranted.

Rationale for using cool dialysate to prevent IDH

During Hemodialysis with standard dialysis temperatures (≥37°C), core temperature increases despite net energy loss over the extracorporeal system. This phenomenon is not fully understood. It may be partly due to reduced heat loss from the skin resulting from vasoconstriction in response to a decline in blood volume. The increase in core temperature leads to subsequent dilatation of resistance and capacitance vessels in the skin, antagonizing the physiologic response to hypovolemia. However, this hypothesis has recently been challenged. In order to prevent this increase in core temperature, a significant amount of thermal energy, amounting to 30% of daily resting energy expenditure, has to be removed by the extracorporeal circuit by cooling the dialysate. Various randomized cross-over trials showed that dialysis with cooler dialysate temperatures (in most studies 35°C) was associated with improved reactivity of peripheral resistance and capacitance vessels, increased myocardial contractility, reduced BP decline and reduced frequency of IDH compared with dialysis with dialysate temperatures of 37–37.5°.

Cool temperature dialysis was found to be equally effective in the prevention of IDH compared with sodium profiling and use of midodrine, however Cool dialysis may lead to shivering.

The increase in core temperature during dialysis may be prevented without cooling the patient by feedback technology.

Isolated ultrafiltration followed by isovolumic dialysis may actually increase the risk for IDH because of the high ultrafiltration rates.

Summarizing, cool temperature dialysis and temperature-controlled feedback are effective in preventing IDH without clinically significant side effects. In order to reduce side effects such as shivering, the panel advises to reduce dialysate temperature from 36.5°C downward until an optimal effect is reached. There is limited evidence and unproven benefit of reducing dialysate temperatures less than 35°C.

Increasing dialysis time enables the reduction of ultrafiltration rate, which will lead to a more gradual decline in blood volume

Midodrine is an oral alpha-1 agonist. The metabolite of midodrine, desglymidodrine, induces constriction of both resistance and capacitance vessels (starting dose 2.5 mg 30 min before dialysis, maximal dose 10 mg) is effective and probably safe in preventing IDH, although data on long-term safety are lacking. However, the superiority of midodrine above other interventions has not yet been shown. Evidence for the effectiveness and safety of other vasoactive drugs is limited.

Rationale on Nutrition

Dietitians are qualified professionals and experts in the application of science in nutrition and metabolism. Training includes interview and counselling techniques. They enable patients to adapt their

regular diet to a diet that includes individual requirements for maintenance Hemodialysis (MHD), based on personal circumstances while also recommending nutritional support as and when needed. Most but not all patients will have received nutritional assessments and counselling prior to starting MHD. It is most important to adjust their diet as soon as possible, preferably within 1 month. All dietary information provided should be in writing and details should be recorded in the patient's care plan. It is essential to evaluate and modify individual dietary regimens after a further month or sooner as needed. Stable MHD patients should be interviewed every 3 or 6 months according to age (<50 years, every 6 months, >50 years every 3 months, and dialysis vintage (<5 years, every 6 months, >5 years every 3 months, as indicated to improve dietary compliance. Hospitalized patients and patients requiring naso-gastric tube feeding or intra-dialytic parenteral nutrition (IDPN) should be assessed within 2–3 days and require follow-up at least once weekly for 2 weeks or until stable. Thereafter follow-up and monitoring can be extended to once per month or as required.

Serum albumin is recommended for routine measurement because a large body of literature is available, that defines normal serum albumin values and characterizes the clinical factors affecting serum albumin concentrations. Serum albumin, per se, is an indicator of visceral protein stores. During recent years the interactions between inflammation and malnutrition status became complex, as inflammation and dietary protein intake exert competing effects on serum albumin levels.

A number of publications demonstrate the relationship between serum albumin concentrations and outcome. Hypoalbuminemia is a predictor of future mortality and cardiac disease at the time of initiation of dialysis and at any time during dialysis treatment. Among patients enrolled in the HEMO study, those in the low albumin group had significantly greater prevalence of coronary heart disease. Serum albumin should not fall below 40 g/l (measured by the bromocresol green method). Patients with a serum albumin level below 35 g/l have a relative mortality risk of, or a 2-year survival of 20% as compared with a 2-year survival of 80% in those with a serum albumin greater than 40 g/l.

Serum albumin levels are not only affected by poor energy and protein intake, but also by other factors including inflammation, catabolic and anabolic processes, age, comorbidity, fluid overload (i.e. plasma volume) and urinary albumin losses. Albumin synthesis is reduced during the acute phase response. The presence of acute or chronic inflammation limits the specificity of serum albumin as a nutritional marker. Measurements of serum albumin levels is inexpensive, easy to perform and widely available.

Protein requirements

During routine Hemodialysis, protein requirements do not appear to be sufficient for the following reasons. First, the dialysis treatment induces a loss of nutrients (glucose, amino acids, vitamins and trace elements) through the dialysis filter, which may even be more important today in response to the use of more porous membranes and/or more efficient techniques such as hemofiltration. Second, the dialysis procedure itself is a catabolic event responsible for protein catabolism (fragmentation of albumin, release of pro-inflammatory cytokines, role of heparin). For example, in response to the rapid decrease in plasma amino acid at the start of the Hemodialysis session, muscle proteolysis occurs in order to maintain an adequate plasma and cellular amino acid concentration. This catabolic event may lead to muscle wasting over the long term. Feeding patients during the dialysis session through regular meals, special liquid feeding or parenteral administration has been shown to revert this catabolic state and should be used as frequently as possible during a standard three-weekly dialysis schedule, food intake was recently reported to be spontaneously reduced by 40% on the last day of the long interdialytic interval, probably in order to avoid fluid overload.

Is a protein intake greater than 1.2 g/kg/day harmful in chronic Hemodialysis?

Although larger protein intakes may not improve nutritional status, they may possibly be associated with better survival:

Protein intake and CKD mineral and bone disease

Elevated protein intakes are not dissociable from an increase in dietary phosphate, which has led some investigators to warn against a potential increase in vascular calcification. Most clinical trials have specifically addressed the question of dietary phosphate restriction only in CKD stages 2 and 3, well before end-stage renal disease (stage 5), in an attempt to prevent secondary hyperparathyroidism. Once dialysis treatment is started however, the relationship between dietary phosphate and

hyperphosphatemia is less straightforward, since bone metabolism and intestinal absorption become the focus of complex interactions and new therapeutic interventions underlining the predominant importance of the dialysis dose over the protein intake in controlling serum phosphate and the phosphocalcic product. Many individuals may have a high serum phosphate without eating a large quantity of proteins, possibly from a greater intestinal fractional absorption of phosphate and the influence of vitamin D therapy, and these patients may better benefit from oral phosphate binders than from a reduction in their protein intake. In contrast, low serum phosphate is frequently associated with low protein intake in patients undergoing regular 4-h or shorter Hemodialysis sessions.

Protein intake and frequency of Hemodialysis

The frequency of the dialysis sessions should be considered when analyzing nutritional intake. Indeed, fear of overload or pulmonary edema may significantly limit food intake during the interdialytic interval, particularly during the long 3-day period. Switching patients to a daily Hemodialysis program, either long nocturnal or short 2 h, has been reported to augment protein intake up to 40%, an increase that was sustained over 1 year and associated with improved serum albumin in almost all pilot studies. The reason for this improved nutrient intake is probably the lifting of the fluid restriction and other general limitations of food intake, especially for those nutrients containing phosphate and/or potassium.

Protein intake and inflammation

Inflammation, which has been repeatedly reported in 20–50% of routine Hemodialysis patients, may impair nutritional status by different mechanisms such as increased anorexia and/or protein catabolism. Controversial debate occurs as to whether protein intake may reverse impaired nutritional status in the presence of chronic inflammation. It is possible to increase serum albumin over 6 months in Hemodialysis patients by simple dietary counselling, and this improvement also occurred when chronic inflammation was present Thus, the relationship between chronic inflammation, dietary intake and nutritional status still remains unclear but may suggest that malnourished inflamed patients may benefit from increased protein intakes.

When protein intake averaged 1.1 g/kg/day or more, most patients showed neutral or positive balance. These observations have led many investigators to recommend a safety level of protein intake of 1.2 g/kg BW/day. After publication of previous nutritional guidelines in renal disease, sporadic reports have challenged these recommendations, by reporting good nutritional status in patients eating less protein. These observations may have been obtained in selected patients, and for the safety reasons detailed above, lower levels of protein intake should not be recommended for the general dialysis population.

Recommendations for vitamins, and trace elements administration in MHD patients

Due to insufficient evidence from clinical trials for recommending administration of vitamins, the following information only reflects the expert's opinion and cannot be considered as a clinical guideline but a recommendation.

Vitamins

Abnormal renal metabolism, inadequate intake and/or gastrointestinal absorption and dialysis losses, account for vitamin deficiencies amongst dialysis patients. Losses are even greater with High-Flux and high-efficiency dialysis. Vitamin deficiency progresses slowly depending on body stores, nutritional intake and chronic dialysis losses. Vitamin status in individual patients depends on age, gender, actual vitamin intake, previous supplementation, dialysis losses, residual renal function, time on dialysis and types of dialyzers in addition to impaired metabolism. Ideally vitamin supplements should be tailored to individual needs. Overt clinical manifestations include depressed immune system, neuropathy and impaired amino acid and lipid metabolism, mild scurvy and other abnormalities. The most frequently observed vitamin disturbances concern water soluble vitamins and these may be supplemented daily or administered after dialysis, three times weekly, which promotes compliance.

Water-soluble vitamins

Thiamine (B1). A daily supplement of 1.1–1.2 mg thiamin hydrochloride is recommended.

Rationale: Thiamine deficiency is responsible for beriberi, a rare condition in MHD patients. Vitamin B1 deficiency may also be evoked in case of atypical neurological symptoms (Wernicke encephalitis). Thiamine is strongly removed during Hemodialysis. Thiamine plasma concentration may not reflect its

biological activity. Thiamine intake in MHD patients can range from 0.6 to 1.5 mg/day depending on individual food consumption. Patients with a poor nutritional intake, as may occur in the elderly, are most likely to benefit from supplementation. Thiamine has been administered in amounts up to 300 mg/week in patients undergoing High-Flux Hemodialysis. Presently, all renal multivitamin formulas include thiamine, from 1.5 mg.

Riboflavin (B2)

A daily supplement of 1.1–1.3 mg is recommended.

Rationale: Although it is well cleared during Hemodialysis, not tightly bound to proteins, riboflavin deficiency is uncommon. A supplement of 1.1–1.3 mg is equal to the recommended daily allowance of healthy people and is sufficient to supplement inadequate nutritional intake and dialysis losses. Riboflavin is contained in milk, bread and cereals, lean meat and egg.

Pyridoxine (B6)

A daily supplement of 10 mg as pyridoxine hydrochloride is recommended.

Rationale: There is evidence that plasma and red cell pyridoxine levels are low in MHD patients. Although the pyridoxine recommended dietary allowance in healthy adults is 1.3–1.7 mg, the use of erythropoietin (EPO) may increase requirements because of increased erythropoiesis. Some drugs and other substances interfere with pyridoxine metabolism, an additional cause for deficiency. A decreased level of pyridoxine may be associated with hyperhomocysteinemia, but the benefit of supplementation is as yet unclear. Pyridoxine is contained in yeast, cereal buds, green vegetables, egg yolk and meat. A supplement of 10 mg/day is recommended as this is the lowest pyridoxine hydrochloride dose that has consistently normalized pyridoxine deficiency and the transamination activation index of stable MHD patients. High doses of pyridoxine hydrochloride (200–600 mg daily) should be avoided as these have been associated with peripheral neuropathy.

Ascorbic Acid (vitamin C)

A daily supplement of 75–90 mg is recommended.

Rationale: Vegetables and fresh fruit are the main sources of vitamin C, but these foods are often restricted or need to be avoided in a potassium restricted diet, resulting in an inadequate intake. In addition, vitamin C is inactivated by heat during cooking. Vitamin C is readily removed by serum levels fell by 30–40% after a single dialysis session and losses from 80 to 280 mg per dialysis session have been reported. Vitamin C deficiency contributes to a mild form of scurvy sometimes seen in MHD patients, may lead to abnormal amino acid metabolism and disturbances in folic acid metabolism. Vitamin C supplements appear to improve functional iron deficiency and hence the response to EPO.

Folic Acid (Folate, vitamin B9)

A daily supplement of 1 mg folic acid is recommended.

Rationale: In MHD patients, folic acid levels may be reduced in serum and red blood cells and induce megaloblastic anemia. Folic acid is contained in yeast, liver, green vegetables, fruit and meat. Because of impaired intestinal absorption, or drug interaction and dialysate losses, particularly with high flux/high efficiency dialysis, it is prudent to prescribe 1 mg folic acid/day to prevent deficiency. This may be insufficient to lower elevated plasma homocysteine levels as the administration of 5–10 mg/day has shown a plasma homocysteine reduction by 30–50. Indeed, the National Kidney Foundation Task Force on Cardiovascular Disease issued a report with recommendations for treatment of hyperhomocysteinemia. It was recommended that MHD patients should receive daily 5 mg folic acid, 50 mg pyridoxine and 400 μg vitamin B12, to reduce serum homocysteine levels and protect against cardiovascular disease.

B12 (cobalamin)

A daily supplement of 2.4 μg vitamin B12 is recommended.

Rationale: Vitamin B12 or cobalamin, combined with the gastric intrinsic factor, are necessary factors for an optimal folate metabolism, a normal non-megaloblastic erythropoiesis and to avoid nervous system demyelination observed in pernicious anemia. Cobalamin is found in sufficient amounts in meat, liver, seafood, milk and egg yolk. Vitamin B12 undergoes an enterohepatic cycling. Most MHD patients present plasma levels of cobalamin in the normal range, whether they receive vitamin B12 supplements or not. Administration of vitamin B12 has been shown to improve or correct nerve conduction

velocity in MHD patients having low vitamin B12 plasma levels. Vitamin B12, when administered for 1 mg monthly, is also efficient in decreasing serum homocysteinemia by ~10%. Since there is no clear report of vitamin B12 toxicity even for high vitamin B12 doses, that is 2.5 mg three times weekly, and because some dialysis patients have an intake below the daily requirements, a daily supplement of vitamin B12 equal to the requirement, for example 2.4 μg/day, seems safe.

Niacin (vitamin B3, nicotinamide, nicotinic acid, vitamin PP)

A daily supplement of 14–16 mg niacin is recommended.

Rationale: Niacin is contained in meat, fish, dry vegetables, coffee and tea. A deficit in niacin store results in signs of pellagra, a dermatosis associated with diarrhea and dementia, as soon as 50–60 days after a complete dietary niacin removal. However, pellagra has never been reported in a chronic dialysis patient. Niacin undergoes a rapid metabolic clearance and does not seem to be cleared by dialysis. Pharmacological niacin doses improve lipid profile by increasing serum HDL and decreasing LDL cholesterol fraction and serum triglycerides. Since many MHD patients have limited intakes of food containing niacin, it is recommended to supplement patients with the required allowance of normal adults, for example 14–16 mg daily.

Biotin (vitamin B8)

A daily supplement of 30 μg biotin is recommended.

Rationale: Major sources of biotin (vitamin B8) include yeast, egg yolk, liver, soybean, mushrooms and cauliflower. Biotin deficiency may be responsible for depression, somnolence, hyperesthesia, anorexia and dermatosis, symptoms often present to a certain extent in MHD patients. In renal patients, a decrease in intestinal biotin absorption has been reported, as well as a plasma biotin decrease during the dialysis session. Furthermore, food intakes that are low in protein are also low in biotin and do not meet the minimal daily biotin requirement. An adequate biotin intake has been proposed at 30 μg/day, and for the aforementioned reasons, it seems prudent to recommend this value also to MHD patients.

Pantothenic acid (vitamin B5)

A daily supplement of 5 mg pantothenic acid is recommended.

Rationale: Pantothenic acid is widely spread in many foods including liver, kidney, fresh vegetables and egg yolk. It plays an important role in β-oxidation, free fatty acid and amino acid oxidation and protein acylation. To date, there is no clear information on pantothenic acid stores for MHD patients. Pantothenic acid is cleared by dialysis, and although no data are yet available, newer more efficient techniques might increase pantothenate losses. Since diets low in protein may not provide the adequate daily needs (5 mg/day), it is recommended that MHD patients take a supplement of 5 mg/day. Further research is warranted on pantothenic acid dialysate losses and stores in dialysis patients.

Fat-soluble vitamins

Vitamin D is not considered in this section as its metabolism, effect and administration in MHD patients depend on phosphocalcic metabolism and bone status and has been the focus of a recent set of guidelines.

Vitamin A (retinol)

A daily intake of 700–900 μg is recommended.

Vitamin A supplements are not recommended.

Rationale: Vitamin A is found in dairy products, fish oil, liver, spinach and carrots. Vitamin A is necessary for night vision and epithelium maintenance. Serum plasma levels of vitamin A are elevated in patients with chronic kidney disease. Vitamin A is not removed during MHD and deficiencies are rare and mostly related to inadequate nutritional intake. Vitamin A toxicity includes hypercalcemia, anemia and hypertriglyceridemia. In order to prevent vitamin A toxicity, supplements containing larger amounts than 700–900 μg/day should not be given to MHD patients. Patients receiving total parenteral nutrition (TPN) may require vitamin A supplements, but not greater than 700–900 μg/day.

Vitamin E (alpha-tocopherol)

A daily supplement of 400–800 IU is recommended in secondary prevention of cardiovascular events and for preventing recurrent muscle cramps.

Rationale: Vitamin E is a strong antioxidant and cell membrane protector. Vitamin E is mainly found in vegetable oils (corn, sunflower and soybean) and wheat germs. Vitamin E plasma levels are not influenced by

the dialysis session, and no vitamin E is found in the spent dialysate. There is no decrease in vitamin E plasma levels in long-term MHD patients.

Vitamin K

A daily intake of 90–120 µg is recommended.

There is no need for vitamin K supplementation, except in patients receiving long term antibiotic treatment or those with altered coagulant activity; a daily amount of 10 mg vitamin K may be temporarily administered.

Rationale: Vitamin K is contained in green leaves vegetables (cabbage, spinach) and cow milk. Vitamin K undergoes intestinal reabsorption through enterohepatic cycling, which may be reduced during oral antibiotic administration. Vitamin K is essential in promoting synthesis of II, VII, IX and X coagulation factors but also of some coagulation inhibitors such as factor C, S and Z. Vitamin K is a cofactor for the γ-carboxylation of glutamate in proteins (GLA-proteins) such as the matrix GLA-protein and osteocalcin, explaining a potential role of vitamin K deficiency in patients with bone fractures. Diets rich in vitamin K1 and vitamin K2 are also often high in potassium and phosphorus, respectively, both of which must be restricted in CKD patients. Thus, it has been suggested that vitamin K deficiency in CKD patients may be due, in part, to a low overall intake of vitamin K. The daily recommended allowance for healthy individuals is 90–120 µg. The data basis for the detrimental input of vitamin K deficiency on extraosseous calcification processes is constantly growing stronger over time with an added another important hypothesis-generating piece to this complex puzzle. It should strengthen any preventive measures prohibiting an inadequate vitamin K status by dietary advice, supplementation, and the avoidance of antagonism.

Minerals

Phosphate (phosphorus)

A daily intake of 800–1000 mg phosphate is recommended.

Dietary education improves phosphate control.

Dietary phosphate control should not compromise protein intake.

Rationale: Dietary phosphate intake should be restricted in MHD patients to avoid hyperphosphatasemia leading to secondary hyperparathyroidism. Foods with a high protein content may contain 12–16 mg phosphate per gram protein, with dairy products having the highest ratio. Thus, a protein intake of 80 g (optimal for a MHD patient weighing 70 kg) will bring about 1100 mg phosphate daily. Since 40–80% of the oral phosphate load will be absorbed, depending on vitamin D administration, the net phosphate gain for 2 days will be 800–1700 mg. Because one standard Hemodialysis session can only clear 500–700 mg phosphate, this will result in a positive phosphate balance, an increase in calcium–phosphate product, an increase in serum parathyroid hormone and a greater cardiovascular risk. However, compromising protein intake at the expense of phosphate restriction should be avoided. Foods high in protein but with the least amount of phosphate should preferably be prescribed through a detailed dietitian interview. Hyperphosphatasemia should be treated by intensive counselling, by increasing phosphate binders and by reviewing the dialysis regimen as appropriate.

More frequent dialysis sessions (e.g. short daily or long nightly schedules) have been reported in pilot studies to improve control of hyperphosphatemia despite increased protein and phosphate intake Longer duration of dialysis ('t' from Kt/V) also helps to improve control serum phosphate, as well as increasing the dialysis membrane surface.

Calcium

The total intake of elemental calcium should not exceed 2000 mg/day including calcium obtained from calcium-based phosphate binders.

Rationale: Calcium intake may be limited due to dietary phosphate restriction (milk and dairy products). Overall, a mean food calcium intake is comprised between 500 and 800 mg/day. However, other sources of calcium include calcium-based phosphate binders, and thus the total daily intake of calcium could be much greater, leading to a positive calcium balance, vascular calcifications and episodes of hypercalcemia. For these reasons, the total amount of oral calcium intake including calcium-based phosphate binders should not exceed 2000 mg daily, and non-calcium phosphate binders should be used if hyperparathyroidism is not controlled.

Sodium and fluid

A daily intake of no more than 80–100 mmol (2000–2300 mg) sodium or 5–6 g (75 mg/kg BW) per day of sodium chloride is recommended.

Interdialytic weight gain (IDWG) should not exceed 4–4.5% of dry body weight.

Rationale: The importance of controlling interdialytic weight gain (IDWG) by restricting dietary sodium (and fluid intake) and the preference for using lower sodium dialysate, has been described in the Hemodynamic Instability.

With progressive loss of urine output, sodium and fluid restrictions are vital to control extra cellular volume, blood pressure and to prevent excessive IDWG in anuric and oliguric MHD patients. By reducing the sodium load from diet and dialysate, the lesser urge for patients to quench their thirst improves compliance with fluid restriction and reduces IDWG. A reduction in sodium intake to 80–100 mmol/l (5–6 g salt) in addition to lowering the dialysate sodium concentration from 140 to 135 mmol/l appears to be sufficient to suppress thirst and hence excessive weight gain. This also benefits blood pressure control and might result in the withdrawal of antihypertensive treatment in some patients.

The majority of dietary sodium, 70–80%, is derived from salt and mono sodium glutamate added to food at home, in restaurants and food outlets or by food manufacturers. Examples of some convenience foods are ready to eat meals, cured meat and fish products, canned and processed foods. The salt content of some staple foods such as breakfast cereals (i.e. cornflakes), bread, butter and margarine and sandwich fillings contribute significantly to dietary sodium intake.

In anuric patients, each 8 g NaCl (140 mmol Na+) requires 1 L of fluid intake to maintain normal serum sodium. Dietary Na+ intake (mmol) may be calculated from average daily fluid weight gain (kg)× average serum Na+ concentration (mmol/l). An 80 kg dialysis patient with 4% IDWG, will have 12 g NaCl intake per day. Current guidelines for daily fluid intake vary from 500 to 1000 ml in addition to daily urine output to achieve an IDWG of 2–2.5 kg or 4–4.5% dry body weight. Some dialysis centers include the amount of 'hidden' fluid in food in fluid allowance prescriptions. Individual fluid allowances need to be adapted for patients living in warmer climates, during periods of hot weather, working in hot environments and as a result of clinical conditions (high fever). However, it is more efficient to carefully monitor salt rather than fluid intake, since as a response to salt intake, thirst will regulate the subsequent fluid ingested.

All foods that are liquid at room temperature (18–20°C) should be counted as fluid except oil and foods with a high fat or sugar content. Reducing sodium and fluid in addition to a potassium and phosphate restriction and ensuring that protein and energy intake is adequate, is difficult and a stepwise approach to educate the patient is most important. MHD patients must be advised to avoid those convenience foods that contain potassium chloride or other potassium containing additives to replace salt.

Potassium

In patients with a pre-dialysis serum potassium greater than 6 mmol/l, a daily intake of potassium of 50–70 mmol (1950–2730 mg) or 1 mmol/kg IBW is recommended.

Rationale: Hyperkalemia is a potential cause of sudden death in MHD patients. There are no warning signs and when pre-dialysis serum potassium levels approach 6 mmol/l, nutritional counselling to lower dietary potassium is indicated, in addition to Calcium Resonium. However, other causes for hyperkalemia should also be investigated and corrected such as metabolic acidosis together with a review of drug therapies that contribute to hyperkalemia such as angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, spironolactone, β-blockers, NSAIDs and other contributing drug therapies. Tissue destruction (e.g. catabolism) as a result of trauma or weight loss releases potassium from intracellular space and results in hyperkalemia in Hemodialysis patients.

Trace elements

Zinc (Zn): A daily nutritional intake of 8–12 mg of elemental zinc (Zn) for women and 10–15 mg for men is recommended. Routine zinc supplementation is not recommended.

A zinc supplementation of 50 mg Zn element per day for 3–6 months should be considered in Hemodialysis patients with a chronic inadequate protein/energy intake and symptoms evoking zinc deficiency

(impaired taste or smell, skin fragility, impotence, peripheral neuropathy).

Rationale: Zinc deficiency is rare in western countries since zinc is absorbed in large quantities from protein rich foods such as red meat, fish and shellfish, milk and milk products, poultry and eggs. Zinc is albumin bound and plays an important role in protein, carbohydrate, energy, nucleic acid and lipid metabolism.

Early signs of deficiency include defects in rapidly dividing tissues such as skin, intestinal mucosa and immune response, decreased taste acuity with a loss in taste buds, impotence, glucose intolerance and hyperlipidemia. Taste and smell impairment associated with chronic uremia contributes to anorexia leading to a reduced food intake that includes protein and may result in zinc deficiency. Zinc deficiency in uremic patients may contribute to peripheral neuropathy. Oral iron supplements, calcium-based phosphate binders and corticosteroids may promote zinc deficiency. Zinc supplementation should be given for at least 3 months since shorter trials did not show expected improvements on taste or immune system. It was shown in a 3-month randomized crossover trial that zinc supplementation, 50 mg Zn element per day for 90 days significantly increased serum zinc level from low to normal and also increased nPCR and serum cholesterol. In more observational reports, nerve conduction velocity improved with zinc supplementation as well as sexual potency but not all studies have confirmed this.

Zinc sulphate is a gastric irritant and should be taken with meals. Zn acetate, Zn aspartate and Zn chloride seem to be better tolerated even on an empty stomach.

Selenium (Se): A daily intake of 55 μg of selenium is recommended.

Routine selenium supplementation is not recommended.

A selenium supplementation for 3–6 months should be considered in Hemodialysis patients with symptoms evoking selenium deficiency (cardiomyopathy, skeletal myopathy, thyroid dysfunction, hemolysis, dermatosis).

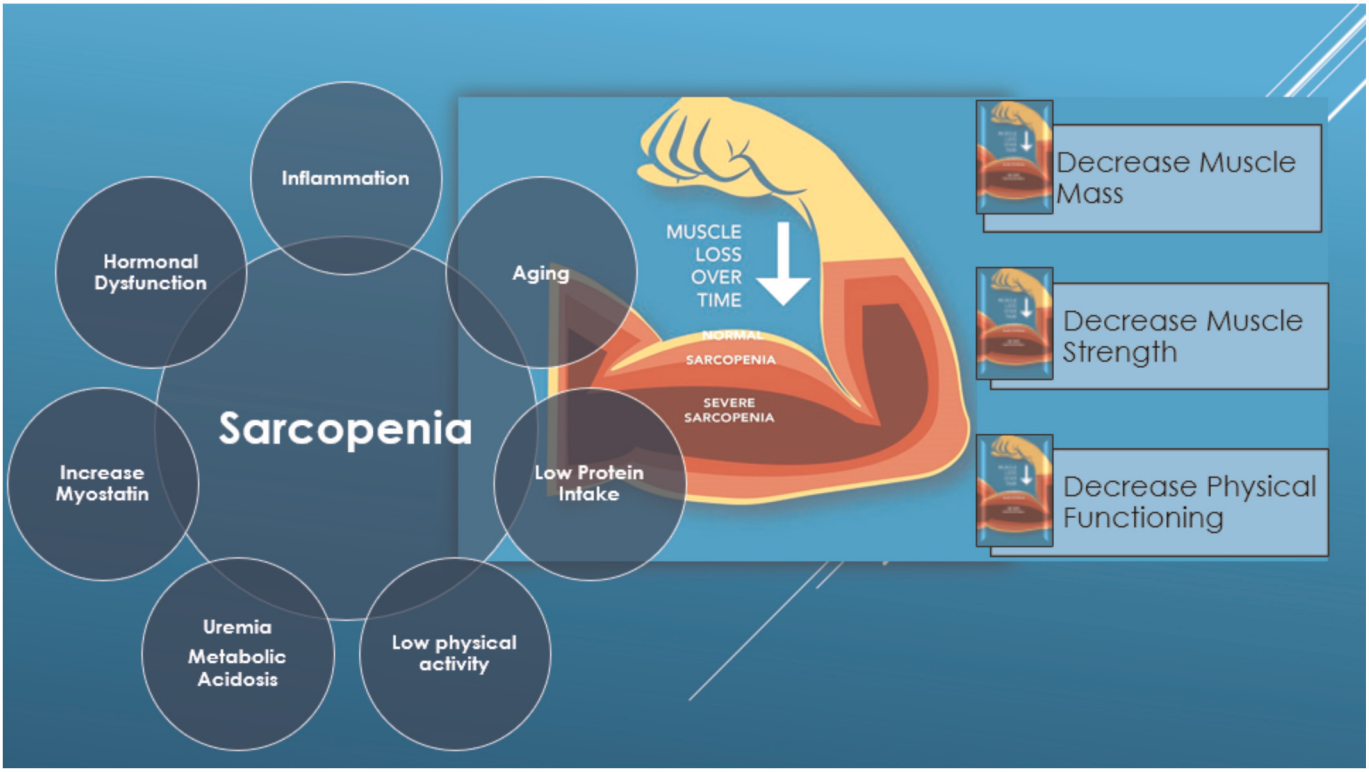
Rationale Selenium is an essential trace element leading to an adequate glutathione peroxidase (GPX) activity that protects cells from lipid peroxidation. Thyroid function regulation depends on selenium. The recommended intake for healthy males and females is 55 μg/day. In case of acute oxidative stress, selenium needs may increase up to 100–150 μg/day. Intestinal absorption is thought to be 50–65%. The main sources of selenium are meat, fish, fat, vegetables and cereals. Other clinical symptoms of altered selenium metabolism include skeletal muscle dystrophia, hemolysis and dermatosis.

Low serum selenium in CKD and MHD patients are not uncommon. There is no recommendation for selenium supplementation for CKD patients but if prescribed, selenium levels should be monitored closely, as selenium is excreted by the kidney and not removed by dialysis. Selenium supplementation might be helpful in partially improving thyroid function in MHD patients. Administered selenium intravenously as sodium selenite in six MHD patients, 50 μg at the end of the dialysis session three times weekly for the first 5 weeks then 100 μg for the next 15 weeks. This treatment was able to increase serum selenium levels and restore glutathione peroxidase activity to normal.

L-Carnitine

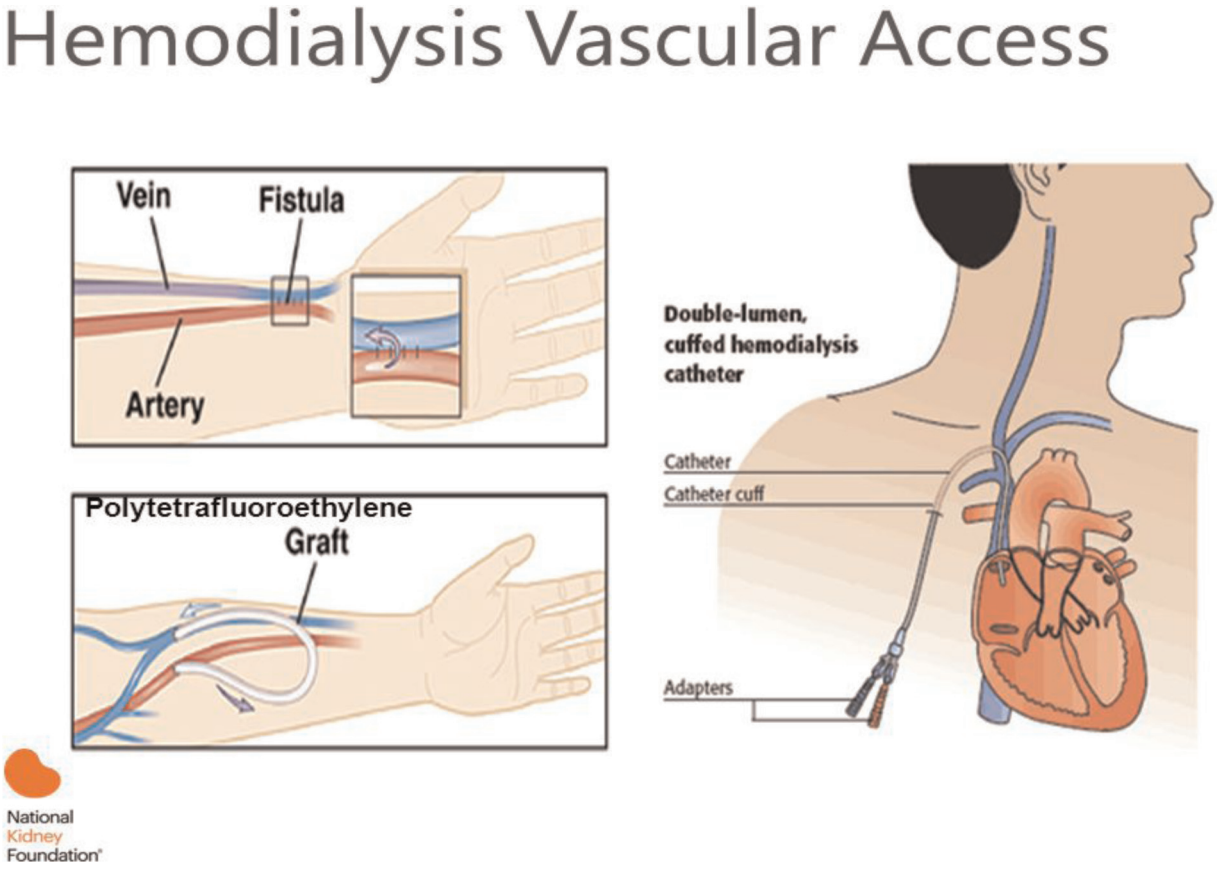
There is insufficient evidence of efficacy to recommend use of L-carnitine in the management of anemia in patients with CKD. The role of carnitine deficiency in the pathogenesis of the anemia of CKD, if any, is unclear. The absence of high-quality evidence for efficacy and safety supports the opinion that there is insufficient evidence to recommend use of L-carnitine in the management of anemia in patients with CKD.

Causes of sarcopenia in Hemodialysis Patients (improving by limiting its causes)



Guideline II

Vascular access



II-Vascular access

Ahmed Elkoraie, *MD, Professor of Nephrology, Alexandria University.*

Guideline II

Vascular access

(1) Creation of Hemodialysis Access:

1.1: Stage 4 CKD patients [GFR <30 ml/min or Creatinine more than 3.0 mg/dl (in most of cases)] should be educated on all modalities of kidney replacement therapy options (KRT) including transplantation and placement of a permanent dialysis access.

1.2: In CKD patients stage 4 or 5, forearm and upper-arm veins should not be used for any venipuncture.

1.3: Patients should have a functional permanent access at the initiation of dialysis therapy.

1.4: Comorbid conditions such as congestive heart failure, diabetes mellitus or peripheral vascular diseases may limit options for access construction.

(2) Selection and Placement of Hemodialysis Access:

2.1: The access should be placed distally and in the upper extremities whenever possible (Fistula: radio-cephalic then brachiocephalic then transposed brachial basilic vein), (AVG: forearm loop graft then Upper-arm graft).

2.2: Options for fistula placement should be considered first, followed by prosthetic grafts if fistula placement is not possible. Catheters should be avoided for HD and used only when other options listed are not available.

(3.1) Arterio-Venous Fistula (AVF); creation rules:

3.1.1: Doppler mapping is mandatory before AVF creation in most if not all of cases.

3.1.2: Venography or another imaging modality such as CT or MRI should be used in those patients in whom there is the potential for central venous stenosis, particularly those with prior subclavian vein catheterization or pacemaker insertion.

3.1.3: The effect of radiographic contrast on pre-dialysis renal failure should also be taken into consideration in the choice of imaging modality.

3.1.4: Fistula should be placed at least 6 months before the anticipated start of HD treatments.

3.1.5: Mature fistula: *Rule of 6:* flow greater than 600 ml/min, diameter at least 0.6 cm, not more than 0.6 cm deep, and discernible margins.

3.1.6: If a fistula fails to mature by 6 weeks, a fistulogram or other imaging study should be obtained to determine the cause of the problem.

Rationale

Patient assessment before creation of AV fistula

A. Patient history:

- A thorough history is required, querying about previous episodes of central vein.

A. Physical examination:

(1) The presence of all pulsations in upper extremity (axillary, brachial, radial and ulnar) should be evaluated and recorded.
(2) The patient should be examined for evidence of previous central or venous catheterization and for signs of trauma or surgery of the arm, chest or neck, including previous AV access surgery.

B. Imaging studies:

(1) **Doppler ultrasonography:** Doppler ultrasonography, which can measure flow velocity as well as the inner diameter of the brachial and radial arteries and peripheral veins, should be performed in all patients to identify suitable arteries and veins for access placement.
(2) **Venography:** Venography should be reserved for evaluating the central veins, especially in patient with a history of transvenous placement of a pacemaker, physical findings of upper extremity edema, collateral veins around the shoulder or on the chest wall and/or unequal extremity size.
(3) **Arteriography:** Arteriography is indicated when pulses in the desired access location are markedly diminished or absent or there is a more than 20 mmHg difference in near arterial pressure between the two arms.

(3.2) Arteriovenous Fistula; how to use:

3.2.1: After skin preparation, apply a tourniquet to increase the venous pressure, and pull skin taut in opposite direction of needle insertion. Avoid excessive pressure to the cannulation site to prevent flattening of the vessel. Stabilize but do not obliterate the vessel.

3.2.2: For easily palpated vessel, use ~25° angle with the bevel up.

3.2.3: Arterial needle placement can be in antegrade (up or in the direction of the blood flow) or retrograde (down or against the direction of blood flow). The venous needle should always be in the same direction as the blood flow. This prevents excessive pressure at the needle site.

3.2.4: The arterial needle in either direction will not increase the risk of recirculation as long as the access blood flow is greater to the blood pump setting.

3.2.5: Once the vessel has been penetrated:

- Advance the needle slowly with cutting edge facing top of vessel and do not rotate axis.
- Tape the needle at the same angle or one similar to the angle of insertion.
- Remove needle at same or angle similar to angle of insertion, and never apply pressure before needle is out.

3.2.6: This compresses peripheral nerve endings between epidermis and dermis and increases surface tension thereby facilitating smoother incision of skin with less surface area contacting cutting edge of needle. It also enables better stabilization of graft or vessel to be cannulated.

(*Continued*)

(***Continued***)

3.2.7: Any manipulation may traumatize the intima of the vessel. The use of a back-eye needle will eliminate the need to rotate the needle due to poor flows. Pressing the needle shaft flat against the skin moves the needle tip from the desired position within the vessel lumen. Avoid trauma to any intima by dragging cutting edge along it. Avoid pressing cutting edge into intima when applying pressure for HD.

(3.3) Arteriovenous Fistula; how to monitor:

3.3.1: Look, listen with a stethoscope and feel with your fingertips.

(4.1) Arteriovenous Graft (AVG); when to do:

4.1.1: A graft should, in most cases, be placed at least 3 to 6 weeks before the anticipated start of HD therapy.

4.1.2: Grafts generally should not be cannulated for at least 2 weeks after placement and not until swelling has subsided so that palpation of the course of the graft can be performed.

4.1.3: Rotation of cannulation sites is needed to avoid pseudoaneurysm formation.

(4.2) Arteriovenous Graft; how to use:

4.2.1: After skin preparation, pull skin taut in opposite direction of needle insertion. Avoid excessive pressure to the cannulation site to stabilize and prevent flattening of the graft material.

(*Continued*)

(***Continued***)

4.2.2: Use ~45° angle of insertion. Less steep angles increase risk of dragging cutting edge of needle along surface. Steeper angles increase risk of perforating underside of vessel.

4.2.3: Once the vessel has been penetrated, there are basically two methods employed in current practice:

(a) Advance the needle slowly with cutting edge facing top of vessel and do not rotate axis.

(b) For a deep, hard to palpate AVG immediately rotate the axis of the needle 180° and advance slowly with bevel cutting edge facing bottom of the vessel.

4.2.4: Tape the needle at the same angle or one similar to the angle of insertion. Remove needle at same or angle similar to angle of insertion, and never apply pressure before needle is completely out.

4.2.5: Pressing the needle shaft flat against the skin moves the needle tip from the desired position within the vessel lumen. Avoid trauma to any intima by dragging cutting edge along it. Avoid pressing cutting edge into intima when applying pressure for HD.

4.2.6: Any manipulation may traumatize the intima of the vessel. Rotating the axis avoids traumatizing the top of intima and prevents the tip of the needle from entering the backside of the graft material. This should only be utilized when the graft backwall location is difficult to determine and the risk of continuing the needle advancement into the backwall is high.

4.3: Arteriovenous Graft; how to monitor:

4.3: Look, listen with a stethoscope and feel with your fingertips.

Access physical examination (Table 12)

Exam steps	Fistula (Normal)	AVG (Normal)	Stenosis or poor maturation (Abnormal)	Infection or steal syndrome (Abnormal)
Look	Well-developed main venous outflow, no irregular/dilated areas or aneurysm formations, areas of straight vein that can be used for cannulation.	Uniform sized graft in a loop or straight configuration.	Fistula with poor maturation-multiple venous outflow veins (accessory veins), poorly defined cannulation areas.	Infection: Redness, swelling, broken skin, drainage and induration.
	Vessel partially collapses when arm is elevated above head.	No irregular areas or aneurysm formations with organized site rotation used for cannulation sites.	Fistula: Stenosis can occur in artery or any of the venous outflow veins.	Steal Syndrome: Hand of the access limb may appear discolored due to poor arterial blood flow to the hand. Check nailbeds, fingers and hand for skin color changes.
			Look for a Narrowing of the outflow vein or aneurysm formations.	
			Fistula or Graft: Dilated neck veins or small surface collateral veins in the arm or neck above the vascular access	
Listen with a stethoscope	Low pitch continuous diastolic and systolic.	Low pitch continuous diastolic and systolic.	High pitch discontinuous systolic only.	Steal Syndrome: Fistula may have a very strong bruit.
Feel with your fingertips	Thrill at the arterial anastomosis and throughout the entire outflow vein that is easy to compress.	Thrill strongest at the arterial anastomosis but should be felt over entire graft and easy to compress.	Fistula: Pulse at the site of a stenotic lesion. Pulse has a water-hammer feel.	Infection: Warm to touch, swelling.

(*Continued*)

(*Continued*)

Exam steps	Fistula (Normal)	AVG (Normal)	Stenosis or poor maturation (Abnormal)	Infection or steal syndrome (Abnormal)
			Graft: Thrill and/or pulse strong at the site of a stenotic lesion. Pulse has a water-hammer feel.	Steal Syndrome: Feel bilateral limbs (hands and fingers) and compare for the access limb to be the same as the non-access limb.
			A graft with a low intra-access blood flow feels mushy. Local area of the graft that feels mushy or irregular in shape can be a site of aneurysm.	Compare temperature, grip strength and range of motion, and any complaints of pain.
				If the access limb has any major differences than the non-access limb, consider steal syndrome.

(5) Patient education basics:

5.1: All patients should be taught how to:
- Compress a bleeding access.
- Wash skin over access with soap and water daily and before HD.
- Recognize signs and symptoms of infection.
- Select proper methods for exercising fistula arm with some resistance to venous flow.
- Palpate for thrill/pulse daily and after any episodes of hypotension, dizziness, or lightheadedness.
- Listen for bruit with ear opposite access if they cannot palpate for any reason.

5.2: All patients should know to:
- Avoid carrying heavy items draped over the access arm or wearing occlusive clothing.
- Avoid sleeping on the access.
- Insist that staff rotate cannulation sites each treatment.
- Ensure that staff are using proper techniques in preparing skin prior to cannulation and wearing masks for all access connections.
- Report any signs and symptoms of infection or absence of bruit/thrill to Hemodialysis center consultant.

(6) Arteriovenous vascular complications:

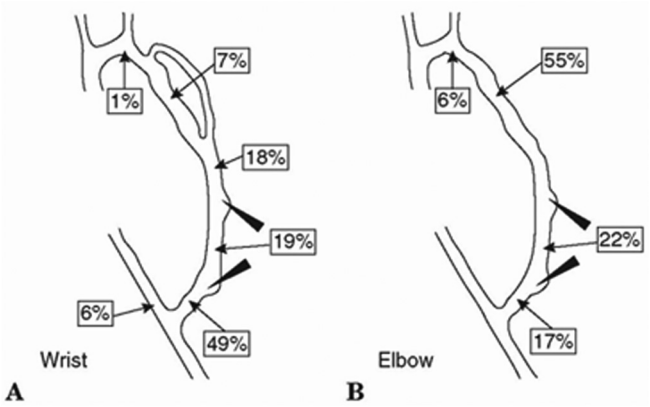
6: Once the AV access has been in use, the most important factors that limit its survival are stenosis, thrombosis, and infection. In general, complications occur more commonly in grafts than in AV fistulas.

Rationale

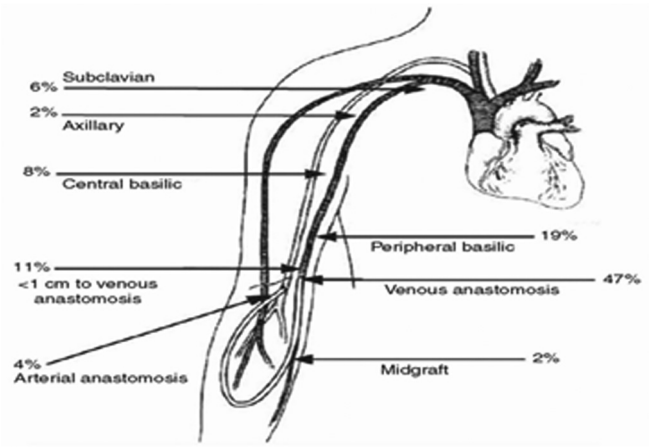
Arteriovenous vascular complications

I. Stenosis:

(a) Vascular access stenosis is a harbinger of thrombosis, reduces access blood flow, and can lead to under-dialysis.
(b) The most common cause of stenosis in AV grafts is neo-intimal hyperplasia, which usually occurs at or just distal to the graft vein anastomosis. In AV fistulas, the location and cause of stenosis is more varied, with the juxta-anastomotic region being a frequent site.



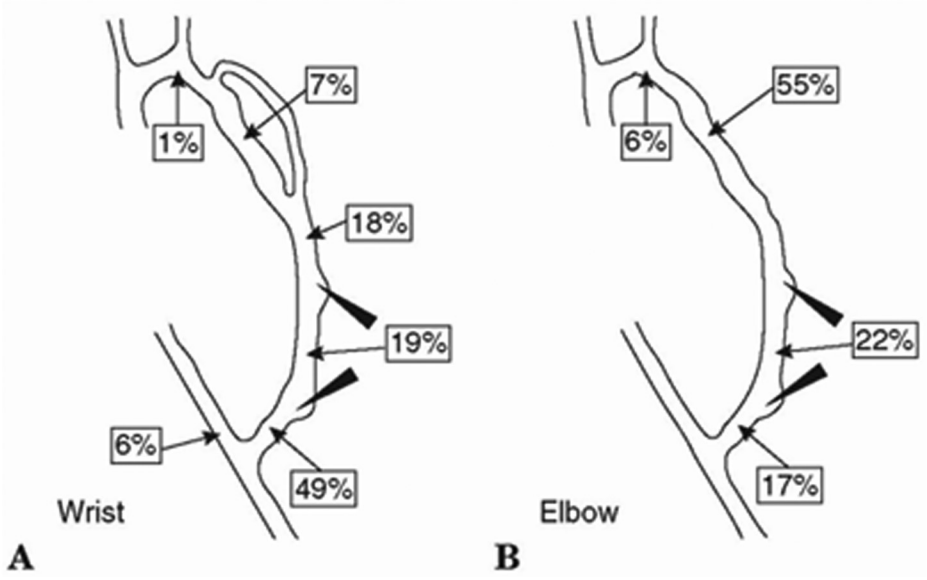
Common sites of stenosis in AV fistula. Locations are shown in fistulae created at wrist (A) and fistulae created at elbow **(B)**.



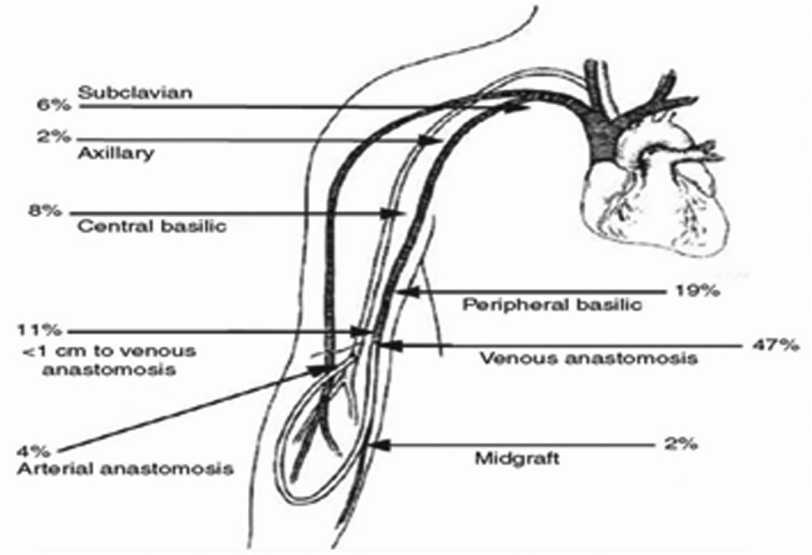
Common sites of stenosis in AV graft.

Common sites of stenosis in AV graft.

Figure 11



Common sites of stenosis in AV fistula. Locations are shown in fistulae created at wrist (A) and fistulae created at elbow (B).



Common sites of stenosis in AV graft.

Arteriovenous fistula and graft stenosis.

(Fig 11: **AVF and AVG stenosis**)

II. Thrombosis:

(1) Thrombosis is the most common complication of arteriovenous access and accounts for 80–85% of access loss.
(2) Causes of thrombosis include stasis of flow, vascular endothelial injury, and altered blood coagulability, but other contributing factors include arterial stenosis, fistula compression, hematoma formation from cannulation injury, hypovolemia, hypotension, and hypercoagulable states.

A. Predisposing factors:

An increasingly recognized number of dialysis patients have subtle accentuations of hemostasis, including high fibrinogen levels, reduced levels of protein S or C, lupus anticoagulant, or elevated hematocrit levels due to erythropoietin therapy. Whether or not these conditions are associated with increased access thrombosis is controversial.

B. Prevention:

Anticoagulants and antiplatelet drugs may help prevent AV access thrombosis.

C. Treatment:

(1) **In AV fistulas***:* Thrombosis of the fistula occurs either soon after its construction or as a late event. Patients should be taught to monitor their fistula daily, when possible. Early thrombosis results from technical factors and almost always requires surgical or percutaneous intervention, although there may be inadvertent compression while sleeping. Poor flow precedes late thrombosis in most cases, but hypotension or hypercoagulability may also precipitate thrombosis in the absence of downward flow trends. Treatment of thrombosis can be difficult but should be performed using either percutaneous methods or surgical thrombectomy, depending on the expertise of each institution. Techniques aiming to remove the bulk of the thrombus have been reported to have a higher success rate.
(2) **In AV grafts:** Thrombosis can be managed by surgical thrombectomy or by mechanical or pharmaco-mechanical thrombolysis, again depending on the expertise of the medical center. Treatment should be performed urgently to avoid the need for temporary access. The entire access circuit should be thoroughly evaluated during the procedure by imaging. Residual stenosis exceeding 85% should be retreated by balloon angioplasty or surgical revision.

III. Ischemia in a limb bearing an AV access:

Dialysis access associated hand ischemia, commonly known as 'steal syndrome,' complicates 1–20% of accesses and can lead to pain, loss of function, and, rarely, the loss of limb. One mechanism of hand ischemia is thought to be 'arterial steal' from retrograde flow in the distal artery toward the access but the presence of arterial stenosis or distal arteriopathy involving small vessels often are contributory. Risk factors include upper arm access, peripheral arterial disease, and diabetes.

A. Detection: Patients with an established fistula should be assessed monthly by interval history and physical examination. Clinically, there is pain, coldness, and paresthesias of distal extremity, especially during dialysis, which can progress to cyanosis, pulselessness, ischemic ulcers, and dry gangrene over days to weeks to months. The onset can be immediately after access creation or insidiously over days to weeks. Examination requires comparison with the temperature, pulse, and function of the opposite hand.

B. Management: Mild ischemia manifested by coldness or paresthesias but without sensory or motor loss can be managed expectantly. Pain of the hand on exercise due to a 'steal' effect (or in extreme instances, pain at rest) or the appearance of nonhealing ulcers usually requires surgical intervention. Loss of motor function of hand is a surgical emergency and surgical evaluation for banding or ligation of the access should be done immediately.

IV. Pseudoaneurysm:

Trauma to AV access from repeated cannulation in the same area can cause damage to all layers of native vein or graft material. Large aneurysms can prevent adequate needle placement and limit potential puncture sites.

V. Infections:

Infection of the access is usually manifested as erythema, pain, or purulent exudate from needle sites. Often, the first sign is fever with no other obvious source and positive blood cultures. The access should not be used if actively infected. Cultures (of blood and of any wound if present) should be taken and antibiotic therapy initiated. The possibility of endocarditis or other sources of infection should be investigated, depending on the pathogen found, and especially if cultures fail to turn negative after antibiotic treatment. Ultrasound evaluation of the tissues around the access is sometimes useful in revealing localized fluid accumulation. An infected access usually requires surgical intervention for debridement or excision.

VI. Congestive heart failure:

Congestive heart failure is unusual with a forearm access but may occur in patients with upper arm or femoral fistulas, particularly if there is coexistent heart disease.

Attention Should be: when the AVF flow more than 2 l by Doppler/or if the flow is more than 30% of the Cardiac output.

(7.1) Catheters; types, when to use and how to insert:

7.1.1: Catheters should be avoided for HD and used only when other options (fistula and graft) are not available.

7.1.2: Tunneled hemodialysis catheters should be used as they are associated with lower rates of catheter-related bacteremia, catheter dysfunction and vascular damage (venous trauma, and stenosis) compared to temporary non-tunneled catheters.

7.1.3: Short-term catheters should be used for acute dialysis and for a limited duration in hospitalized patients. Non-cuffed femoral catheters should be used in bed-bound patients only.

7.1.4: Long-term catheters should be used in conjunction with a plan for permanent access. Catheters capable of rapid flow rates are preferred. Catheter choice should be based on local experience, goals for use, and cost.

7.1.5: The preferred insertion site for tunneled cuffed venous dialysis catheters is the right internal jugular vein. Other options include the right external jugular vein, left internal and external jugular veins, subclavian veins, femoral veins, and trans-lumbar and transhepatic access to the IVC. Subclavian access should be used only when no other upper-extremity or chest-wall options are available.

7.1.6: Long-term catheters should not be placed on the same side as a maturing AV access, if possible. Special attention should be paid to consideration of avoiding femoral catheter access in HD patients who are current or future kidney transplant candidates.

7.1.7: The position of the tip of any central catheter should be verified radiologically.

7.1.8: Tunneled cuffed catheters should have their tips within the right atrium confirmed by fluoroscopy for optimal flow.

7.1.9: Short-term catheter tips should be in the superior vena cava and confirmed by using chest radiograph at the time of placement before initiating dialysis therapy.

7.1.10: There should be a plan to: (i) discontinue, or (ii) convert any short-term catheter to a long-term catheter within 1 week.

(7.2) Catheters; how to use:

7.2.1: The catheter exit site or port cannulation site should be examined for proper position of the catheter and absence of infection by experienced personnel at each HD session before opening and accessing the catheter.

7.2.2: Changing the catheter exit-site dressing at each HD treatment, using either a transparent dressing or gauze and tape.

7.2.3: Using aseptic technique to prevent contamination of the catheter or port catheter system, including the use of a surgical mask for staff and patient and clean gloves for all catheter or port catheter system connect, disconnect, and dressing procedures.

(7.3) Considerations for Accessing Catheters and Cleansing Catheter Exit Sites:

7.3.1: Prepare procedure site using dialysis precautions.

7.3.2: Conduct procedures using aseptic technique (correct handwashing, masks for patient and staff, 'no-touch' technique, and disposable clean gloves).

7.3.3: Chlorhexidine 2% with 70% alcohol is the preferred solution or cleansing of long-term catheter sites.

7.3.3.1: For patients with sensitivities to chlorhexidine 2% with 70% alcohol, chlorhexidine aqueous' may be used instead.

7.3.3.2: For patients with sensitivities to chlorhexidine aqueous, povidone solution be may be used.

7.3.4: Skin cleansing should include the following steps:

- Apply solution/swab in a circular motion working from catheter exit site outwards.
- Cover an area 10 cm in diameter.
- Repeat this step twice. Don't rinse off or blot excess solution from skin.
- Allow solution to dry completely before applying dressing.

7.3.5: To cleanse the connection between any CVC hub and cap use two swabs:

- Grasp connection with 1 swab.
- Use second swab to clean from catheter connection up catheter for 10 cm.
- Cleanse hub connection site and cap vigorously with the first swab. Discard swab.
- Don't drop a connection site once it is cleaned.

7.3.6: To cleanse the section of the catheter that lies adjacent to the skin, gently swab the top and undersides of the catheter starting at the exit site and working outwards. Check catheter manufacturer's warnings about effect of disinfectants on catheter material and use according to manufacturer's directions.

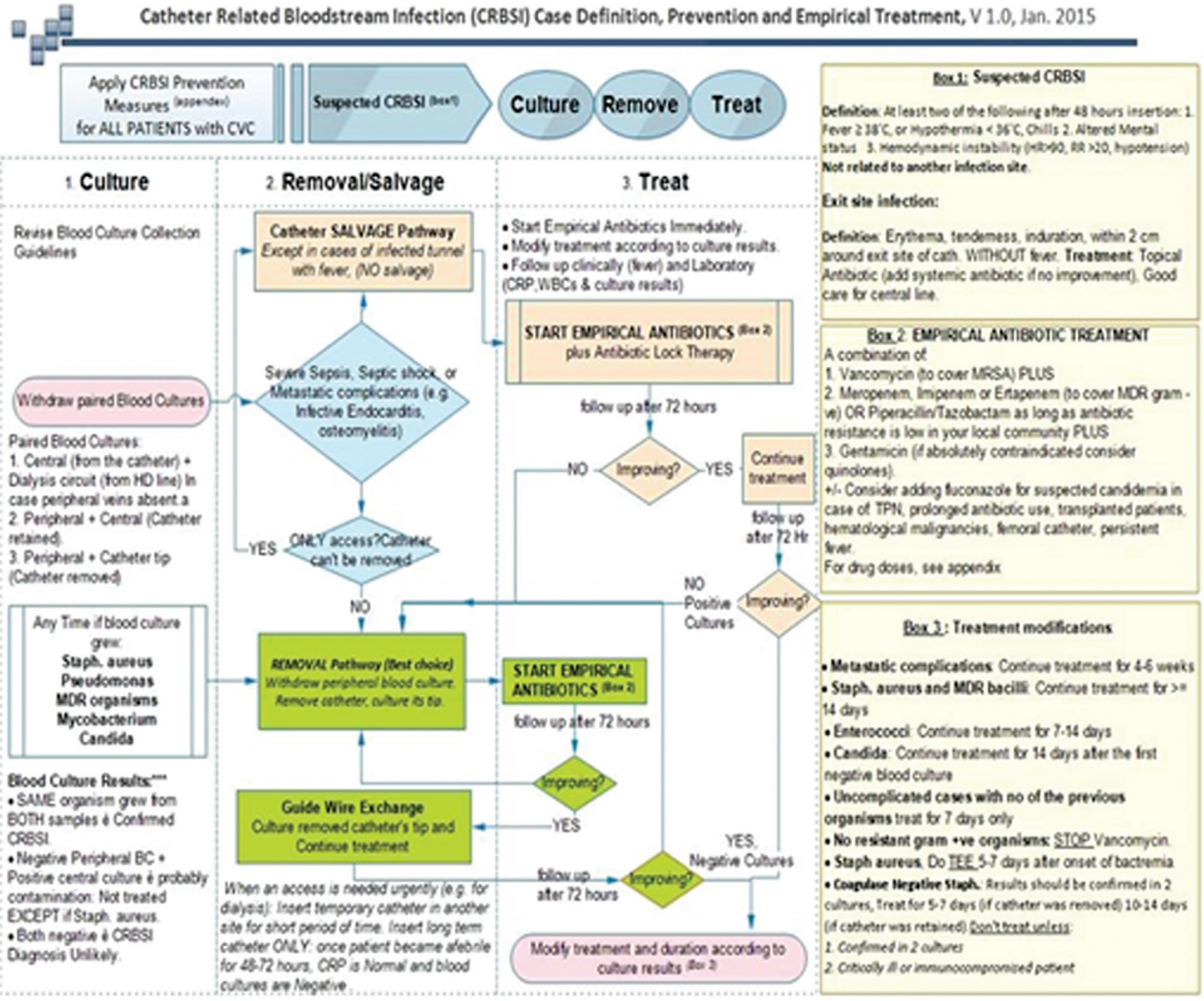
(7.4) Catheter-related blood stream infection (CRBSI) (Fig 12):

7.4.1: Suspect CRBSI in case of isolation of recognized pathogen from blood culture, presence of clinical signs of sepsis and/or shock for more than 48 h and not related to infection in another site. Confirm CRBSI if central and blood cultures yield the same organism.

7.4.2: In case of suspected CRBSI, Culture, remove and treat.

Catheter-related blood stream infection (CRBSI) (Fig 12)

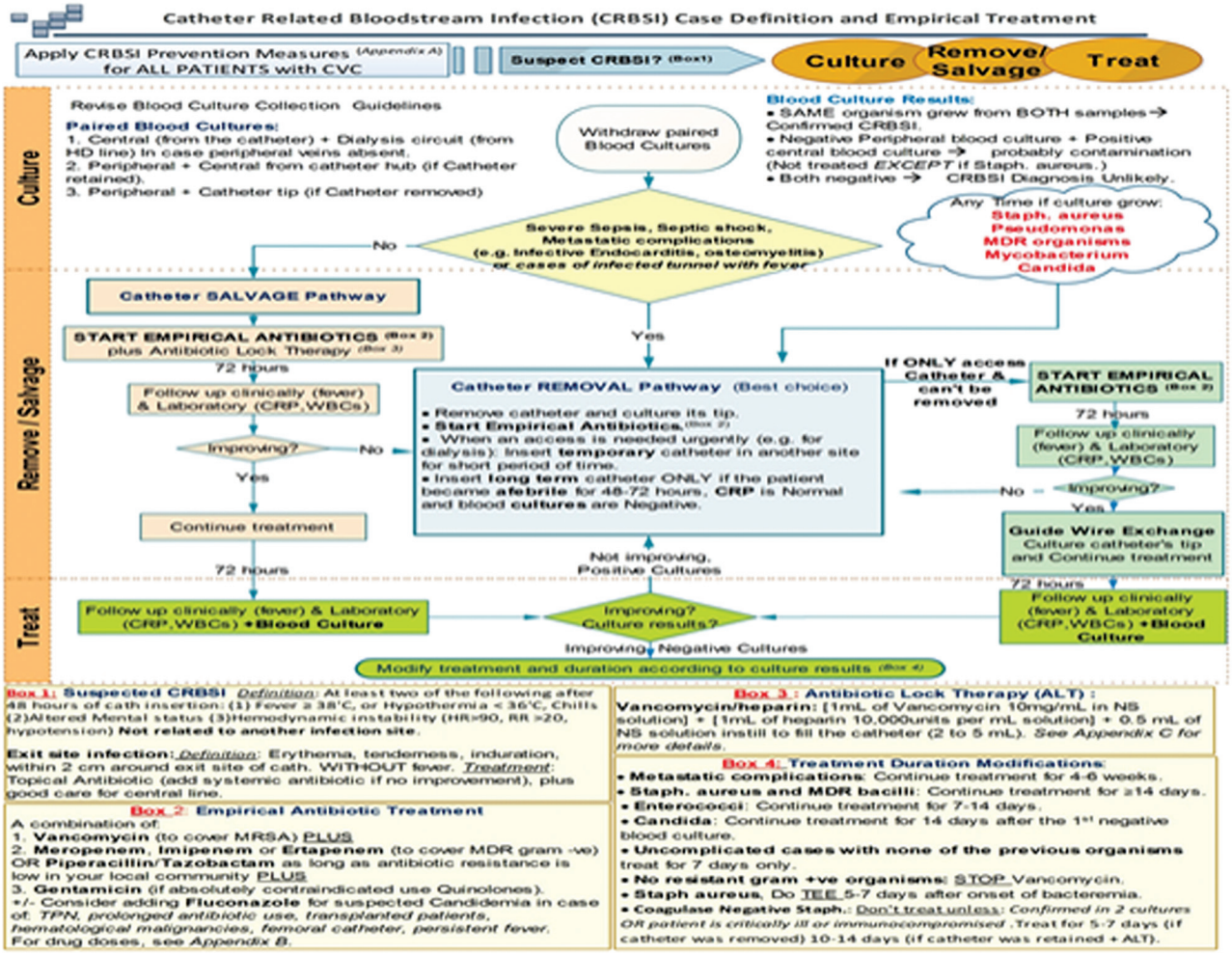
Figure 12



Catheter-related blood stream infection (CRBSI).

Catheter-related blood stream infection (CRBSI) (Fig 13)

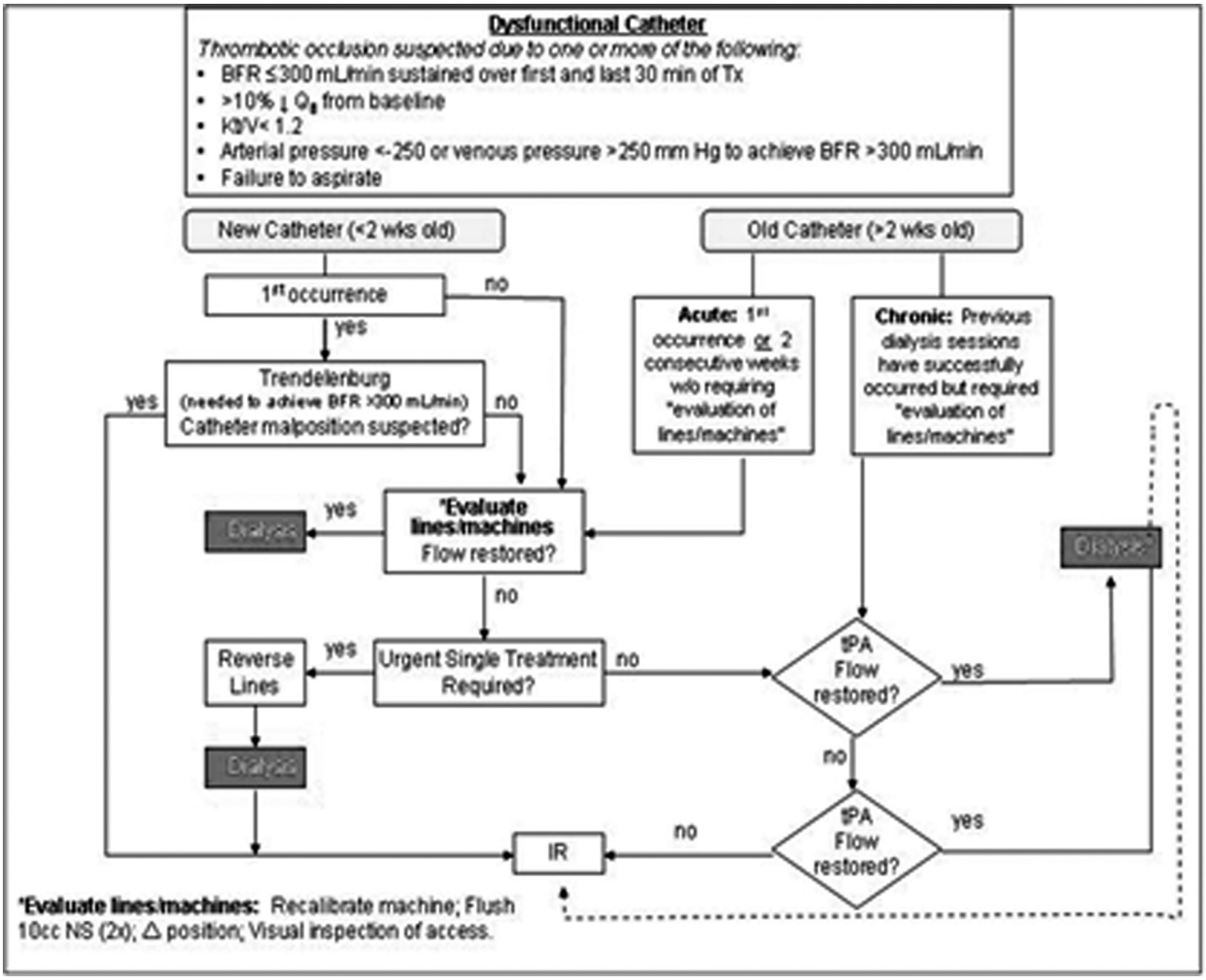
Figure 13



Catheter-related blood stream infection (CRBSI).

(7.5) Catheter dysfunction (Fig 14)

Figure 14



Approach for Catheter dysfunction.

7.5.1: Signs of CVC dysfunction include:

(1) Blood pump flow rates less than 300 ml/min.
(2) Arterial pressure ↑ (<−250 mmHg)
(3) Venous pressure ↑ (>250 mmHg).
(4) Conductance ↓ (<1.2): the ratio of blood pump flow to the absolute value of pre-pump pressure.
(5) URR progressively less than 65% (or Kt/V <1.2).
(6) Unable to aspirate blood freely (late manifestation).
(7) Frequent pressure alarms-not responsive to patient repositioning or catheter flushing.

7.5.2: Trend analysis of changes in access flow is the best predictor of access patency and risk for thrombosis.

Catheter dysfunction (Fig 14)

Preventive antimicrobial catheter locks and catheter surface treatment

(1) Between the dialysis treatment sessions, the central venous catheter can be blocked with diluted heparin solution. However, this solution does not have an antibacterial effect.
(2) Blocking with lock solutions having an antibacterial effect is preferable since it allows the rate of catheter associated bacteremia CRBSI to be reduced significantly.
(3) The main concerns with prolonged use of antibiotic lock solutions are the potential development of antimicrobial resistance and other adverse effects.
(4) In view of the potential risks of spillover of the locking solution, associated risks (arrhythmias,

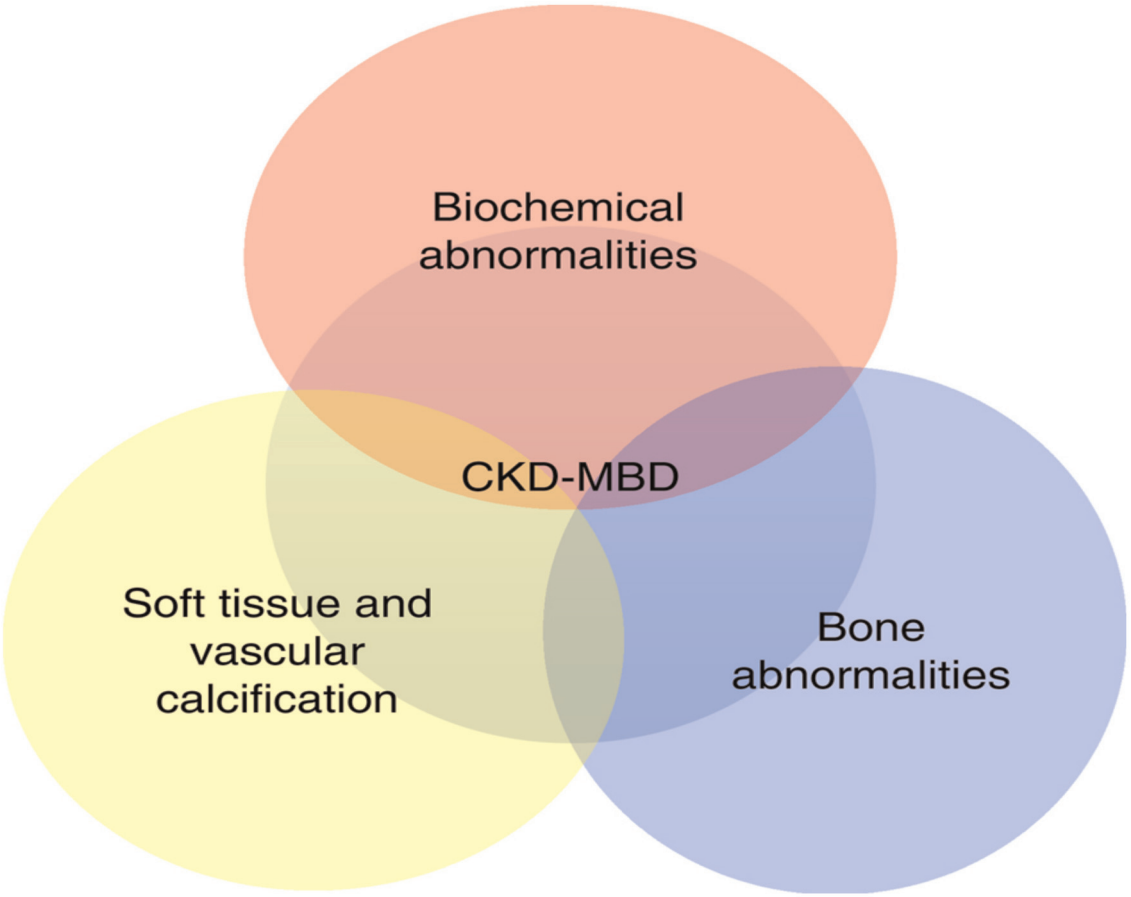
toxicity, allergic reactions, development of resistance to antibiotics) should be balanced with the benefits in terms of prevention of infection.

(5) Citrate locks have, for the time being, most extensively been studied. The 4% solution seems to offer at present the best benefit/risk ratio.

(6) Alternatively, citrate solutions 4% and taurolidine-citrate solutions are conceivable in this regard. Due to the risk of serious cardiac arrhythmias, high dose citrate solutions (30–45 %) must be avoided.

(7) Antimicrobial lock solutions should not replace hygienic standards with regard to catheter care and handling.

Guideline III



Chronic kidney disease – CKD-MBD

III-CKD-MBD

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(1) Diagnosis of CKD-MBD: biochemical abnormalities

1.1: Serum levels of calcium, phosphate, PTH, and alkaline phosphatase activity should be monitored in CKD G3a.

1.2: In patients with CKD G3a–G5D, it is reasonable to base the frequency of monitoring serum calcium, phosphate, and PTH on the presence and magnitude of abnormalities, and the rate of progression of CKD.

Reasonable monitoring intervals would be (Table 13**):**

CKD stage	S. calcium	Ph.	PTH.	Alkaline phosphates	Calcidiol 25 (OH) D
3	Every 6–12 M	Every 6–12 M	Baseline	–	Baseline
4	Every 3–6 M	Every 3–6 M	Every 6–12 M	Every 12 M	Baseline
5	Every 1–3 M	Every 1–3 M	Every 3–6 M	Every 12 M	Baseline
5D	Every 1–3 M	Every 1–3 M	Every 3–6 M	Every 12 M	Baseline

In CKD patients receiving treatments for CKD-MBD, or in whom biochemical abnormalities are identified, it is reasonable to increase the frequency of measurements to monitor for trends and treatment efficacy and side effects.

1.3 In patients with CKD G3a–G5D, 25(OH) D (calcidiol) levels should be measured, and repeated testing determined by baseline values and therapeutic interventions. Vitamin D deficiency and insufficiency can be corrected using treatment strategies recommended for the general population.

1.4 Serum Ca. adjusted for albumin **(corrected Calcium 'CCa')** measured before dialysis should be maintained between **8.4 and 9.5 mg/dl**. Cca can be calculated by adding 0.8 mg to total Ca for every 1 g/l decrease in albumin level below 4 g/dl. **Cca=S.ca+0.8 (4-S. Alb)**.

1.5 Serum Ph. in CKD G3–G5 non-dialysis maintained between **2.78 and 4.64 mg/dl. In CKD G5D maintained between 3.4 and 5.2 mg/dl**.

Rationale:

The majority of studies found phosphate to be consistently associated with excess mortality at levels above and below the limits of normal, but not in the normal range.

1.6 Intact PTH should be between 2- and 9-times upper limit of normal range trend to increase or decrease within accepted range is more important than absolute figure. It is generally considered elevated if above 500.

(2) Diagnosis of CKD-MBD: vascular calcification

2.1 Lateral abdominal Plain X-Ray – Echocardiogram detect valvular calcification.

2.2 Patients with CKD G3a–G5D with known vascular or valvular calcification be considered at highest cardiovascular risk.

(3) Management of CKD-MBD targeted at lowering high serum phosphate and maintaining serum calcium

3.1: In patients with CKD G3a–G5D, we suggest lowering elevated phosphate levels toward the normal range.

3.2: In adult patients with CKD G3a–G5D, avoid hypercalcemia.

3.3: In patients with CKD G5D, we should use dialysate calcium concentration between 1.25 and 1.50 mmol/l (2.5 and 3.0 mEq/l).

3.4: In patients with CKD G3a–G5D, decisions about phosphate-lowering treatment should be based on progressively or persistently elevated serum phosphate.

(*Continued*)

(*Continued*)

3.5: In adult patients with CKD G3a–G5D receiving phosphate-lowering treatment, the dose of calcium-based phosphate binders should be restricted.

3.6: In patients with CKD G3a–G5D, we recommend avoiding the long-term use of aluminum-containing phosphate binders and, in patients with CKD G5D, avoiding dialysate aluminum contamination to prevent aluminum intoxication.

Rationale:

3.3: In patients with CKD G5D, a dialysate calcium concentration between 1.25 and 1.50 mmol/l (2.5 and 3.0 mEq/l) was found to improve bone and mineral parameters compared with the higher concentration of 1.75 mmol/l (3.5 mEq/l).

Lowering dialysate calcium levels slowed the progression of CAC (Coronary Artery Calcification) and improved biopsy-proven bone turnover.

Treatment of hypocalcemia.

(a) In life threating hypocalcemia Cca less than 6.4 mg/dl or Cca (6.4–7.2 mg/dl) with sign of tetany give Ca gluconate IV 5 ml (5 Amp) in 500 ml saline over 12 h.
(b) With no sign of tetany give oral calcium.
(c) If CCa is **7.2–8.4 mg/dl**, giving Ca Carbonate 1000 mg Tds after meal by 2 h or empty stomach.
(d) If associated with hyperphosphatemia, giving calcium-based phosphate binder and Ca acetate is preferred within meal.
(e) If associated with raised PTH, Add 0.5mcg alphacalcidol daily with normal phosphate level.

Treatment of hypercalcemia.

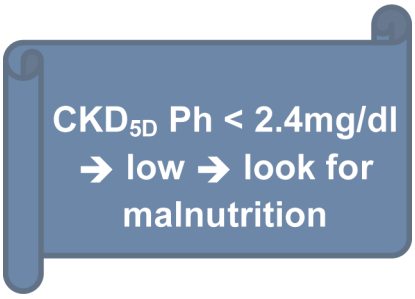
(a) Stop Calcium.
(b) Decrease dialysate calcium.
(c) If associated with hyperphosphatemia, try non-calcium containing Ph binder.
(d) If PTH is low, stop vit. D analog.
(e) If PTH is elevated, stop vit. D analogue and use calcimimetics.

Treatment of hyperphosphatemia.

Average plasma Ph. level in CKD**5D** patients with plasma Ph.

(a) **Less than 2.4 mg/dl** un-equivocally low.
(b) **2.4–4.5 mg/dl** normal.

(c) (More than **4.5–6 mg/dl** mildly raised.
(d) More than **6 mg/dl** significantly raised.



First line treatment: –

(a) Dietary restriction and adequate dialysis with high flux filter or HDF.
(b) Limiting dietary phosphate intake: It is reasonable to consider phosphate source (e.g. animal, vegetable, additives) in making dietary recommendations.

Pharmacological therapy

(a) In absence of hypercalcemia: calcium-based phosphate binders (Ca. acetate, Ca. carbonate, Ca. and Mg).
(b) If Ca. high and Ph. not controlled: non-calcium containing phosphate binders (sevelamer carbonate, sevelamer hydrochloride, should be used in dialysis patient).

(4) Treatment of abnormal PTH levels in CKD-MBD

4.1: In patients with CKD G3a–G5 not on dialysis, the optimal PTH level is not known. However, patients with levels of intact PTH progressively rising or persistently above the upper normal limit for the assay should be evaluated for modifiable factors, including hyperphosphatemia, hypocalcemia, high phosphate intake, and vitamin D deficiency.

4.2: In adult patients with CKD G3a–G5 not on dialysis, calcitriol and vitamin D analogs **should not** be routinely used. It is reasonable to reserve the use of calcitriol and vitamin D analogs for patients with CKD G4–G5 with severe and progressive hyperparathyroidism.

4.3: In patients with CKD G5D requiring PTH-lowering therapy, we suggest calcimimetics, calcitriol, or vitamin D analogs, or a combination of calcimimetics with calcitriol or vitamin D analogs.

- Give Alpha calcidol if Ca and Ph within accepted range (oral pulse) at the end of each dialysis session up to 6 μg/d each session three times a week according to PTH level.
- If associated with hypercalcemia or hyperphosphatemia give cinacalcet 30-60 mg/d and re-assay Ca, Ph, PTH.
- If Ca, Ph decrease to normal range and still PTH elevated stop cinacalcet and give alphacalcidol oral pulse therapy.

4.4: In patients with CKD G3a–G5D with severe hyperparathyroidism (HPT) who fail to respond to medical or pharmacological therapy, we suggest parathyroidectomy.

Management of Hypocalcemia (Table 14**)**

Serum Ca value or clinical symptoms of hypocalcemia	Recommendations
<8.4 mg/dl (2.1 mmol/l) and ? 7.5 mg/dl (1.9 mmol/l), or Persistent symptoms of hypocalcemia Despite attempts to increase serum Ca	Ca-containing P binders, vitamin D sterols, And/or adjustment of dialysis fluid Ca Concentrations can be used to raise serum Ca According to clinical judgment
<8.4 mg/dl (2.1 mmol/l) and ? 7.5 mg/dl (1.9 mmol/l), or in the presence of clinical symptoms of hypocalcemia	Reduce or withhold the dose of cinacalcet
≤>7.5 mg/dl (1.9 mmol/l) or Persistent symptoms of Hypocalcemia and vitamin D cannot be increased	Withhold administration of cinacalcet until serum Ca levels reach 8 mg/dl (2.0 mmol/l) and /or Symptoms of hypocalcemia have resolved. Treatment should be reinitiated using the next lowest dose of cinacalcet

Ca, calcium; P, Phosphate.

Rationale:

4.2: Recent RCTs of vitamin D analogs failed to demonstrate improvements in clinically relevant outcomes but demonstrated increased risk of hypercalcemia.

(5) Management of Osteoporosis with CKD

Definition:

WHO defines osteoporosis as a T score less than –2.5. Or predisposition to low trauma fracture with or without BMD in the osteoporotic range. BMD is measured by DXA. Renal osteodystrophy is a form of osteoporosis.

Treatment of patients with CKD and fractures is difficult, incapacitating and expensive. Thus, there is necessity for nephrologists to treat CKD-associated osteoporosis.

Antiresorptive therapy is effective in patients with creatinine clearance between 15 and 60 ml/min and no evidence of adynamic bone disease, a bone biopsy is not needed.

(1) CKD G1-G2: management as the general population.
(2) G3a-G3b with normal PTH and high risk of fracture: Treatment as the general population.
(3) G3a-G5d with biochemical abnormalities of CKD: Treatment choices consider magnitude

and reversibility of biochemical abnormalities and progression of CKD with consideration of bone biopsy, prior to antiresorptive therapy (as it exacerbates low bone turnover and hypocalcemia).

Osteoporosis is a measurement of bone density, not a diagnosis (Table 15**):**

CKD-MBD	Osteoporosis
Increase PTH and Alk Phosphatase	Normal
Weakly related to fracture	Bone density predicts fracture
Cortical bone loss	Trabecular and cortical bone loss
Adynamic bone may be present	Bone formation normal
Associated with vascular calcification	No
Abnormal Ca, Ph,FGF-23	Normal or mildly increased

(1) Decreased bone formation: Aging, DM, CKD.
(2) Osteomalacia: Vit D deficiency, Al toxicity.
(3) Increased resorption: menopause, hyperparathyroidism.
(4) Both :liver disease, steroids.
(5) Lytic lesions: myeloma.
(6) Abnormal collagen.

(Table 15**)**

Increased risk of fractures in CKD due to:

Hyperparathyroidism, adynamic bone, HD associated amyloidosis, decrease vit D, hypocalcemia, nutritional disturbance, changes in bone architecture, oxidative stress.

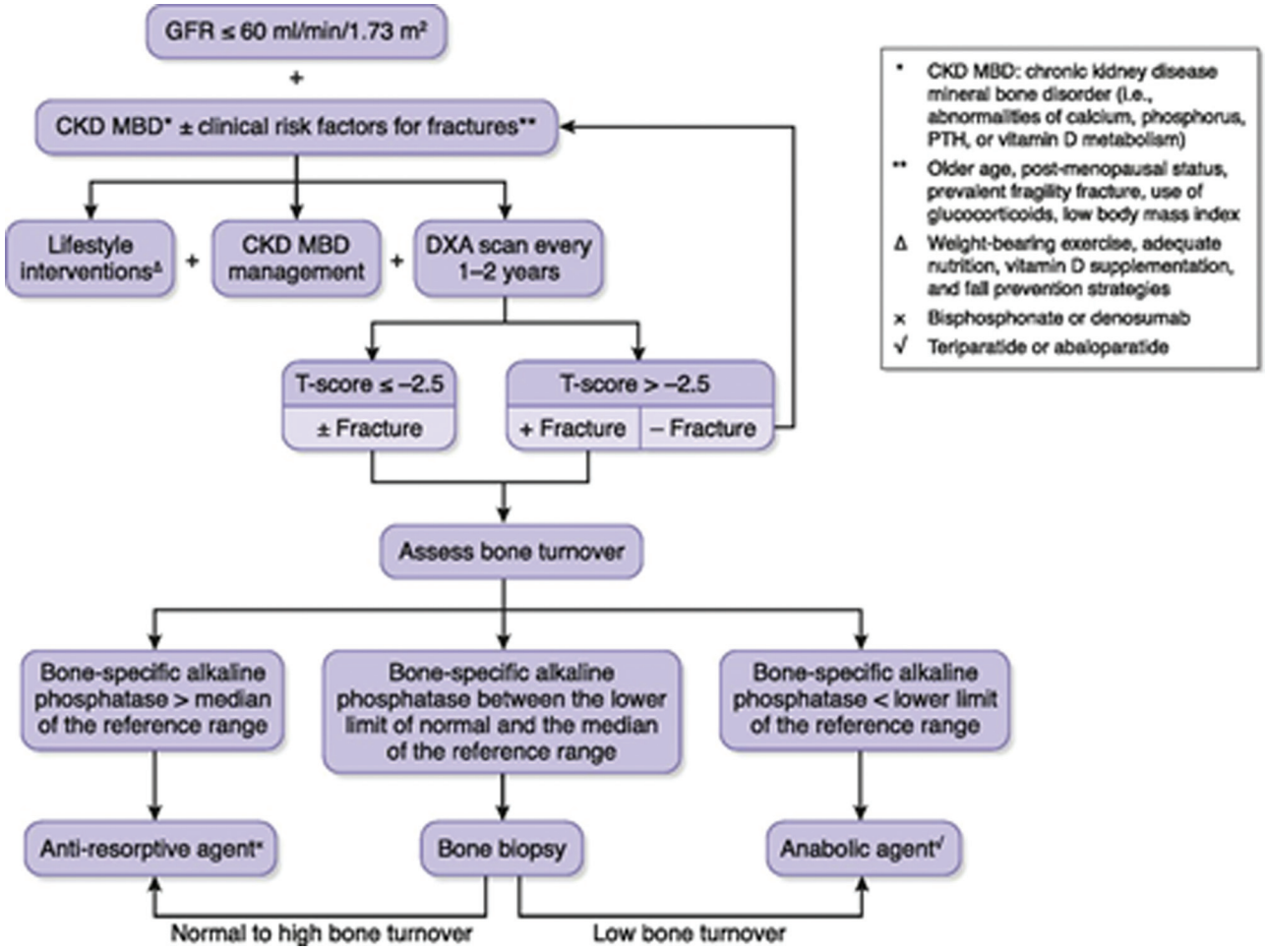
Management of osteoporosis in CKD:

(1) Keep vit D more than 30 ng/ml as it optimizes bone mineralization.
(2) Decrease Ph reverses hypocalcemia and hyperparathyroidism.
(3) Paracalcitriol, vit D analogue, used when increase PTH persists despite treatment of hyperphosphatemia. It decreases PTH with minimal effect on Ca levels and kidney function in stage 3–4.
(4) Cinacalcet can decrease risk of fracture in CKD and 2ry hyperparathyroidism.
(5) Lifestyle interventions for all patients: Ca, vit D, fall prevention, weight bearing exercises, improved nutrition.
(6) Antiresorptives:
Alendronate and Residronate can be used up to stage 3-4, kidney function not affected.
Denososumab: not cleared by the kidney: increase BMD of spine and hip in subjects with GFR 30–60 ml/min dose 60 mg/6 m+ Ca and vit D supplementation.
(7) **Osteoanabolic agents:** not used in high turnover bone disease due to hyperparathyroidism, but in low turnover or adynamic bone disease.
   (a) Teriparatide (forteo), side effects hypercalcemia and hyperuricemia.
   (b) Abaloparatide: analogue of PTH related peptide, less risk of hypercalcemia. No data in CKD-MBD patients.
   (c) New agents :not used until cardiovascular event data are clarified.
   (d) Sclerostin: glycoprotein product inhibits Wnt signaling which is a –ve regulator of bone formation
   (e) Romososumab–Raloxifene.

DXA screening of patients with CKD is evolving, to assess risk of fracture and target them for antifracture strategies. Antiresorptive therapy has efficacy in preventing fractures in patients with creatinine clearance 15–60 ml/min, and do not produce adynamic bone disease, so no need for bone biopsy before starting treatment. Bone biopsy is done when diagnosis of bone turnover is not clear.

(Fig 15) An algorithm for fracture risk screening and initiation of anti-fracture strategies in patients with CKD. CKD-MBD, CKD mineral and bone disease; DXA, dual energy x-ray absorptiometry; PTH, parathyroid hormone.

Figure 15

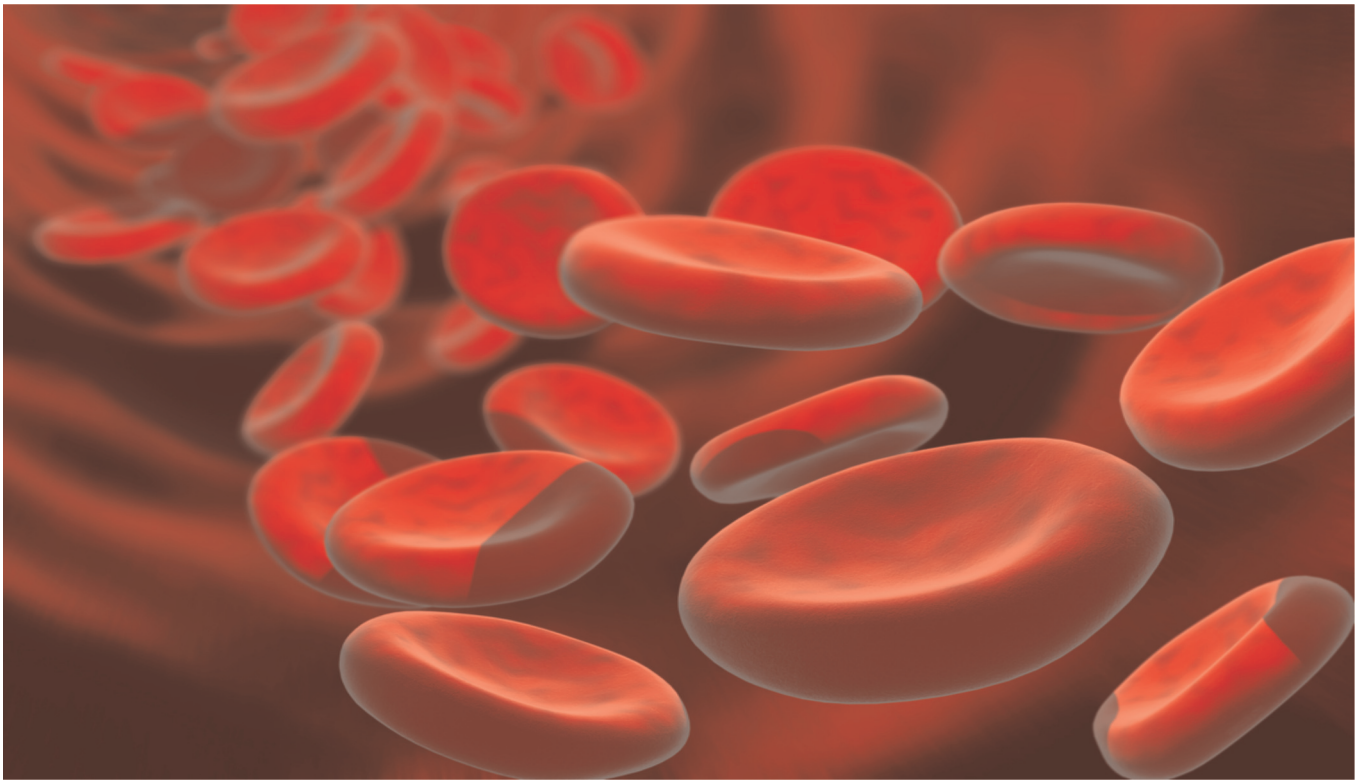


Fracture risk in Hemodialysis patients.

Guideline 1V

Diagnosis and Management of

Anemia in Hemodialysis Patients



IV-Diagnosis and Management of Anemia in Hemodialysis Patients

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(1) Target Haemoglobin and assessment of the cause

1.1 Patients on chronic dialysis should ideally have hemoglobin levels of 10–11 g/dl (in pre-dialysis blood sampling as referred to in HD strategies).

In unit-based hemodialysis patients receiving thrice weekly dialysis, Hb monitoring performed prior to **a mid-week hemodialysis** session would minimize Hb variability due to the longer inter-dialytic interval with consequence of volume load during the long period between dialysis sessions.

The target Hb levels to be maintained are in the range of 10–11 g/dl in the blood

samples collected at the beginning of the week of HD. We recommend initiating the treatment of renal anemia when the Hb level is less than 10 g/dl in several test results.

In the diagnosis of renal anemia, it is necessary to differentiate renal anemia from various hematological diseases that can cause anemia. The following are useful for the differentiation of hematological diseases:

(a) Presence or absence of abnormalities of leukocytes and platelets.
(b) Cytometric categories by MCV (microcytic, normocytic, and macrocytic).
(c) Increase and decrease in reticulocyte count.

1.2 If the Hemoglobin is below 10 g/dl:

Exclude other causes of anemia that are not due to lack of Erythropoietin (ESA) by:

(a) Clinical and laboratory evaluation of anemia should be performed prior to initiation of treatment for anemia in CKD patients.
(b) We recommend that laboratory evaluation should include the following tests:

(1) Complete blood count (CBC) including – in addition to the Hb concentration:
  (a) Red blood cell indices: mean corpuscular Hemoglobin (MCH).
  (b) Mean corpuscular volume (MCV).
  (c) Mean corpuscular hemoglobin concentration (MCHC).
(2) White blood cell count and differential count.
(3) Platelet count.
(4) Absolute reticulocyte count to assess bone marrow responsiveness (if indicated).
(5) Serum ferritin to assess iron stores.
(6) Plasma/serum C-reactive protein (CRP) to assess inflammation.
(7) Based on the initial assessment we recommend in selected cases, the following tests may be useful to diagnose the cause of anemia:

(1) Serum B12 and serum folate concentrations.
(2) Tests for hemolysis (plasma/serum levels of haptoglobin, lactate dehydrogenase, bilirubin, Coombs' test).
(3) Plasma/serum and/or urine protein electrophoresis.
(4) Hb electrophoresis.
(5) Free light chains and bone marrow examination.

Tests to determine iron status:

(a) Percentage of hypochromic red blood cells (% HRC), but only if processing of blood sample is possible within 6 h or
(b) Combination of transferrin saturation (TSAT) and serum ferritin.
(c) Reticulocyte Hb content.

1.3 We recommend that patients should be iron replete to achieve and maintain target Hb whether receiving ESAs or not.

1.4 We suggest that ESA therapy should not be initiated in the presence of absolute iron deficiency (ferritin <100 µg/l) until this is corrected and anemia persists. In patients with functional iron deficiency iron supplements should be given prior to or when initiating ESA therapy.

Low serum ferritin is a useful marker to diagnose absolute iron deficiency. Normal or high serum ferritin values (≥100 µg/l) do not exclude iron deficiency, as it could be due to other causes as infection or inflammation.

1.5: **If transferrin saturation** less than **20% and serum ferritin** less than **100 ng/ml.**

(1) Administer IV iron 20 mg test dose, then 100 mg/session×8–10 sessions and re-assess iron stores.
(2) Maintenance (IV) iron is usually needed (25–100 mg/week) but not more than 300 mg/month to guard against iron overload.
(3) Continue to monitor iron status regularly (once a month until target levels are stable for 2 months than every 3 months).
(4) We recommend that resuscitative medication and personnel trained to evaluate and resuscitate anaphylaxis should be present at each administration of intravenous iron.
(5) Contraindication, careful administration, and notes for iron therapy.
  (a) There are contraindications and precautions for iron therapy.
  (b) Caution should be exercised before initiating iron therapy even if patients meet the criteria for starting treatment.
  (c) Physicians should carefully decide if iron therapy is appropriate for each patient, even if they have iron deficiency.

  In the following cases, iron therapy should be stopped:

  (1) Hypersensitivity to iron agents or additives, such as a history of anaphylaxis caused by iron therapy.A history of diseases or symptoms that might be caused by iron overload, massive transfusion, hemosiderosis, or iron-related disorders. Severe hepatic disorders.Serum ferritin exceed 800 µg/l

In the following cases, iron therapy should be carefully determined considering the benefits and risks of iron administration:

(a) Paroxysmal nocturnal hemoglobinuria: this may induce hemolysis.
(b) The presence of infections: these have been reported to cause complications, such as bacterial infections and mycoses, or exacerbate these infectious diseases. when iron is administered it cannot correct anemia even if they receive the maximum dose of ESA.

Maintain Iron Stores:

(a) Transferrin saturation; 20–50%.
(b) Serum ferritin: 100–500 ng/ml.
(c) We recommend that serum ferritin should not exceed 800 µg/l in patients treated with iron. To achieve this iron management should be reviewed when the ferritin is more than 500 µg/l.

1.6 If the patient has sufficient iron stores, administer ESA.

(1) We recommend that treatment with Erythropoiesis Stimulating Agents (ESAs) should be offered to patients with anemia of CKD who are likely to benefit in terms of quality of life and physical function and to avoid blood transfusion; especially in patients considered suitable for transplantation.
(2) Choice of ESA: We recommend that the decision on the choice of ESA is based on local availability of ESAs and the target Hb response achieved.
(3) Procedure for administration of ESA.
    (a) Start with 25–50 µ/kg 3×/week subcutaneously and monitor hemoglobin every 2 weeks until stable on target, then monthly.
    (b) The initial dose of ESA should be in the lower range (25 µ/kg 3×/week) in patients with any history of thrombosis, uncontrolled hypertension, fits or recent history of cancer.
    (c) Titrate the weekly dose of ESA up or down by about 25% as needed every month by dose reduction or less frequent injection.
    (d) If more than 300 µ/kg SC ESA /week is needed**: evaluate for ESA resistance:**
    (1) Inflammation (CRP).Hyperparathyroidism (PTH).Trace metal (particularly aluminum) overload, check dialysis water quality and Kt/V.Recheck for other causes of anemia again e.g. folic acid and vitamin B12 deficiency.

For patients who are treated with ESA and cannot maintain target Hb levels, we suggest iron therapy if both the following conditions are satisfied:

(a) Absence of disease that decreases iron utilization rate.
(b) Serum ferritin level less than 100 ng/ml or TSAT less than 20%.

The dose and frequency of ESA administration should be determined by considering various factors, such as the type of ESA, the Hb level at the start of administration, the target Hb level, and the expected or target rate of improvement in anemia.

1.7 The management of anemia should consider other factors such as the nutrition of the patient and the adequacy of dialysis.

1.8 Patients with ESA hyporesponsiveness.

Inadequate response ('resistance') to ESA therapy is defined as failure to reach the target Hb level despite.

(a) SC epoetin dose more than 300 IU/kg/week (450 IU/kg/week IV epoetin), or
(b) Darbepoetin dose more than 1.5 µg/kg/week.
(c) Hyporesponsive patients who are iron replete should be screened clinically and by investigations for other common causes of anemia.

Patients with ESA hyporesponsiveness are likely to have poor prognoses. The factors underlying ESA hyporesponsiveness should be carefully examined in patients who show initial or subsequent hyporesponsiveness to ESA.

1.9 Patients on ESA therapy should be carefully monitored for side effects:

(a) Hypertension.
(b) Thromboembolism.
(c) Pure Red Cell Aplasia.
(d) Increases in extracorporeal circulating residual blood volume and the required dose of anticoagulant and evaluate the HD Adequacy due to lower clearance values by high hematocrit.
(e) Solid organ tumors.

1.10 evaluation for ESA induced Pure Red Cell Aplasia (PRCA)

(1) We do not recommend routine screening for anti-erythropoietin antibodies among CKD patients regularly treated with erythropoiesis stimulating agents.
(2) We recommend that the diagnosis of ESA induced PRCA should be considered whenever a patient receiving long term ESA therapy (>8 weeks) develops all the following:

2.1 sudden decrease in Hb concentration at the rate of 0.5 to 1.0 g/dl per week OR requirement of transfusions at the rate of ~1 to 2 per week.

2.2 Normal platelet and white cell counts.

2.3 Absolute reticulocyte count less than 10 000/µl.

2.4 We recommend that all ESA therapy should be stopped in patients who develop ESA induced PRCA.

Causes of erythropoiesis-stimulating agents hyporesponsiveness (Table 16**)**

Cause	Mechanism/Etiology
1- Bleeding and blood loss	Gastrointestinal bleeding, menses, blood trapping in the dialyzer
2- Hematopoietic disorder	1. Infections (including blood access infection and peritoneal access infections)
	2. Aluminum poisoning, lead poisoning
	3. severe hyperparathyroidism (osteitis fibrosa)
	4. Under dialysis
	5. Renin–angiotensin system (RAS) inhibitor
	6. Malignant tumor
Cause	Mechanism/Etiology
3-Deficiency of elements required for erythropoiesis	Iron deficiency (copper deficiency, vitamin C deficiency), folic acid deficiency, vitamin B12 deficiency
4-Hematopoietic organ tumor and hematological disorder	Multiple myeloma, hemolysis, abnormal hemoglobin disease
5-Hypersplenism	Over-Destruction of RBCs
6-Anti-EPO antibody	Antibody (Ab)-mediated pure red cell aplasia (PRCA) is an immunological pathology
7-Other factors	Zinc deficiency, carnitine deficiency, vitamin E deficiency

(2) Red blood cell transfusion

2.1 We suggest that the decision to transfuse a CKD patient with non-acute anemia should not be based on any arbitrary Hb threshold but should be determined by the occurrence of symptoms caused by anemia.

2.2 In hemodynamically stable patient, a blood transfusion should be considered in the presence of stringent indications (i.e. very low Hb levels, Hb values ≤7 g/dl or at Hb values ≤8 g/dl in postoperative surgical patients and in patients with pre-existing cardiovascular disease), clear symptoms related to anemia, ESA resistance, considerable risk using ESA therapy).

Restricted Indications for Blood transfusion

(a) As maintenance therapy for renal anemia with sufficient dialysis, appropriate ESAs, and iron therapy, we recommend minimal red blood cell (RBC) transfusion to improve general condition and symptoms related to anemia.
(b) For patients with rapidly progressing anemia and those who plan to undergo an operation that could induce bleeding, we recommend minimal RBC transfusion.
(c) For patients with symptoms of persistent anemia and ESA hyporesponsiveness, we suggest minimal RBC transfusion.
(d) For patients who cannot receive sufficient doses of ESAs because of collateral side effects, we suggest minimal RBC transfusion.
(e) For patients who are candidates for renal transplantation, we recommend avoiding, when possible, RBC transfusion to minimize the risk of enhanced antibody production (sensitization), which may cause rejection after transplantation.
(f) Written signed consent is required for each transfusion.

Indications for RBC transfusion are restricted to the following cases:

(a) Chronic anemia (including severe anemia), extreme ESA hyporesponsiveness, and difficulty in administering a sufficient dose of ESA because of collateral side effects.
(b) Acute anemia (including rapidly advancing anemia because of bleeding), hemolysis, or a surgical reason.

Standard operating Procedure for Blood Transfusion Refer to SOP Page 22

Fluid consideration: Ensure the blood volume administered is also calculated into the total fluid volume to be removed/ultrafiltrated.

3. Summary of Clinical performance measurement for anemia management in Patients on Dialysis

(a) Proportion of patients starting an ESA without prior measurement of %HRC or CHr (or serum ferritin and TSAT).
(b) Proportion of patients on renal replacement therapy with Hb level less than 10 g/dl who are not prescribed an ESA.
(c) Each renal unit should audit the type, route and frequency of administration and weekly dose of ESA prescribed.
(d) The proportion of patients treated with an ESA with Hb more than 12 g/dl.
(e) Mean (median) ESA dose in patients maintained on ESA therapy.
(f) Each renal unit should monitor ESA dose adjustments.

(g) Proportion of patients with serum ferritin levels less than 100 µg/l at start of treatment with ESA.
(h) Proportion of HD patients receiving IV iron.
(i) Prevalence of resistance to ESA among renal replacement therapy patients.
(j) Proportion of HD patients who received a blood transfusion within the past year.

Rationale

Although relative erythropoietin deficiency is common among patients with anemia and CKD, other potential causes should be identified or excluded. A clinical and laboratory evaluation of the cause of anemia should precede initiation of ESA therapy.

The recommended laboratory evaluation aims at assessing:

(a) The degree and cause of anemia.
(b) Bone marrow responsiveness.
(c) Iron stores and iron availability for erythropoiesis.

Anemia due to causes other than erythropoietin deficiency should be suspected when:

(a) The severity of the anemia is disproportionate to the deficit in renal function.
(b) There is evidence of iron deficiency.
(c) There is evidence of hemolysis.
(d) There is evidence of bone marrow disorder as manifest by leucopoenia and/or thrombocytopenia.

Sampling Rationale

In CKD patients not yet requiring dialysis and in those on peritoneal dialysis (PD), the timing of the blood sample draw is not critical because plasma volume in these patients remains relatively constant. In Hemodialysis (HD) patients, one issue remains to be clarified. Hemoglobin concentrations are routinely measured in dialysis patients before dialysis. This potentially leads to lower hematocrit values as a result of dilution from fluid overload prior to ultrafiltration and an underestimation to actual hemoglobin value.

Interdialytic weight gain contributes to a decrease in Hb level, whereas intradialytic ultrafiltration leads to an increase in Hb level. Thus, a pre-dialysis sample underestimates the euvolemic Hb level, whereas a post dialysis sample over-estimates the euvolemic Hb. Indeed, changes on hematocrit can vary from the start to the end of dialysis by up to 6% depending on the volume of ultrafiltration.

In unit-based hemodialysis patients receiving thrice weekly dialysis, Hb monitoring performed prior to a mid-week hemodialysis session would minimize Hb variability due to the longer inter-dialytic interval between the last treatment of 1 week and the first of the next.

Assessment of Bone Marrow Responsiveness

In general, anemia of CKD is normochromic and normocytic and is morphologically indistinguishable from the anemia of chronic illness. Initial assessment of anemia in CKD patients should aim at identifying other factors that may influence the response to treatment.

In addition to Hb, other indices of the FBC report may provide important clinical information:

(a) Macrocytosis could be due to folate or vitamin B12 deficiency.
(b) In addition to anemia of CKD, microcytosis could be due to iron deficiency or hemoglobinopathies.
(c) Macrocytosis with leucopoenia or thrombocytopenia could be due to several factors such as alcohol intake, nutritional deficit (vitamin B12 or folate deficiency), or myelodysplasia.
(d) Serum folate is more prone to variation and can be affected by the patient's diet immediately prior to blood being taken, alcohol, trauma and other factors therefore occasionally red cell folate may need to be measured where serum folate is equivocal.
(e) Hemolysis is suggested by the presence of macrocytosis, high lactate dehydrogenase and positive Coombs test.
(f) The normal absolute reticulocyte count ranges from 40 000 to 50 000 cells/µl. Although it has a significant inter-patient variability, this test may be useful as a semi-quantitative marker of erythropoietic activity.

Evaluating Iron Status in Anemic Patients with CKD

(a) The aim of evaluating iron status is to assess iron level in tissue stores and the adequacy of iron utilization for erythropoiesis.
(b) Serum ferritin level is the only available blood marker of storage iron.
(c) There are several tests to assess adequacy of iron for erythropoiesis: TSAT, MCV, MCH, percentage

of hypochromic red blood cells (HRC) and reticulocyte Hb content (CHr) or Ret-Hb.

Tests limitations

(a) HRC estimation is a useful test for assessment of iron availability but is limited by the effect of sample storage time and need for special analyzers.
(b) Long sample storage time (>6 h) may spuriously increase HRC. Because a fresh sample is needed, this measure may not be practical in routine clinical practice.
(c) If using percentage of hypochromic red blood cells from a fresh sample is not possible, reticulocyte Hb content (CHr) or Ret-Hb could be a suitable alternative.
(d) If testing for CHr (or Ret-Hb) is not feasible, it is preferable to test ferritin and TSAT together because the combination provides an important insight into erythropoiesis, iron storage and iron availability to bone marrow.
(e) Low serum ferritin is diagnostic of iron deficiency. High serum ferritin, in addition to expressing the adequacy of iron stores, could be due to inflammatory conditions. TSAT is influenced by nutritional status, timing and inflammation. TSAT is also limited by high day to day variations.

IV Iron Therapy

The aim of iron treatment targets is to optimize anemia therapy while minimizing potential toxicity. Therapy targets aim at:

(a) Minimizing the ESA dose required to maintain target Hb levels in patients on ESA therapy and;
(b) Maximizing the Hb level and minimizing the need to initiate ESA therapy to achieve target-range Hb levels in patients not on ESA therapy.

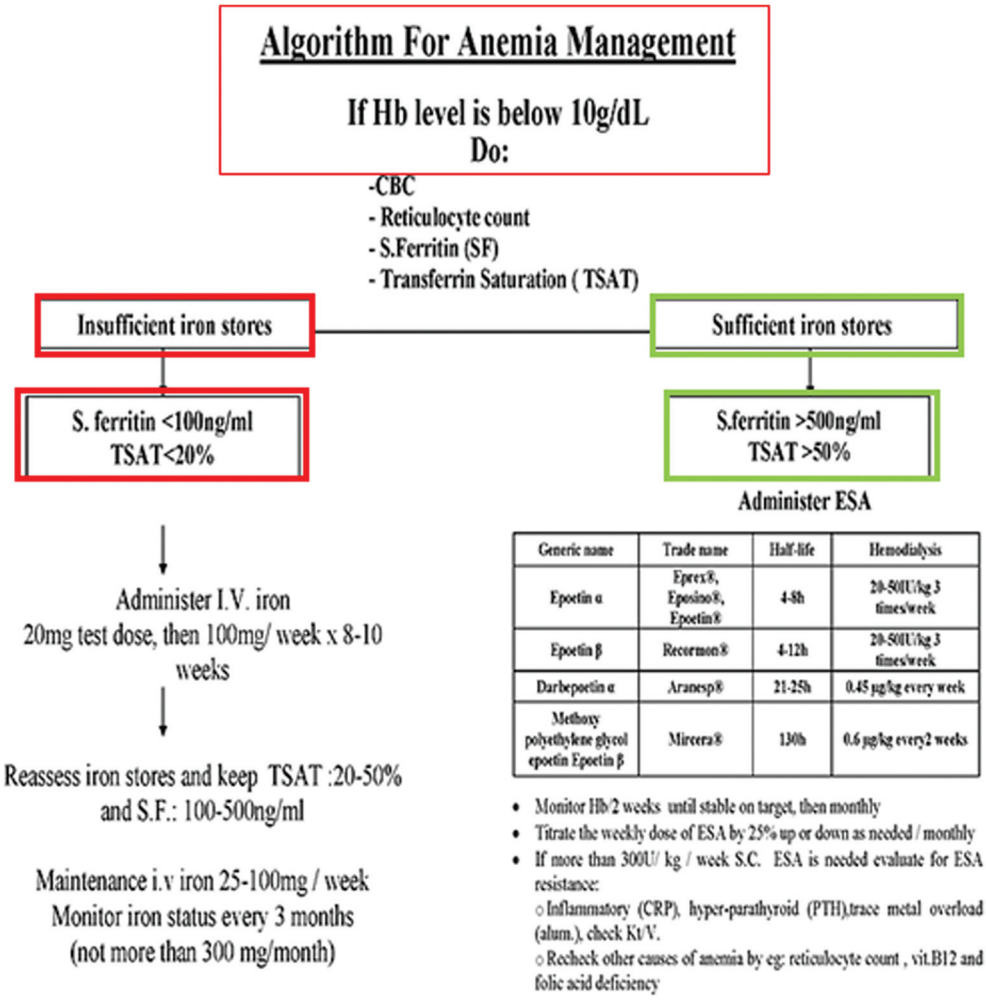
Treatment of Anemia with iron therapy – upper limit for iron therapy

Rationale

(1) Iron overload is defined as increased total body iron content with the possible risk of organ dysfunction.
(2) There is no clinically available method that accurately determines total body iron content.
(3) An elevated serum ferritin does not always correlate with elevations in liver iron content.
(4) Magnetic resonance imaging provides a reliable assessment of tissue iron content in HD patients regularly treated with parenteral iron. However, the clinical relevance of increased liver iron remains unclear.
(5) Elevated serum ferritin together with elevated serum transferrin saturation remain the most clinically accurate parameters of iron overload in CKD patients.
(6) Discontinuation of adequate maintenance IV iron when an individual's ferritin is more than 500 μg/l produces a population mean that straddles the 500 μg/l ceiling. Ongoing iron therapy in patients with ferritin more than 500 μg/l results in a higher median ferritin outcome.
(7) Interpretation of iron status results and deciding on the need for further iron therapy should include a concomitant assessment of changes in Hb level and ESA dose over time. Examples:
    (a) A dropping ferritin as well as decreasing Hb levels signifies blood loss, for example on HD or bowel related anemia: iron therapy is indicated; further investigation may be required depending on the clinical scenario.
    (b) A decreasing ferritin level after initiation of ESA therapy, with a concomitant rise in Hb level indicates a response to ESA with a shift of iron from stores to bone marrow: further iron therapy is guided by target ferritin level.
    (c) An increasing ferritin level after reduction of ESA dose to bring Hb level down to target range indicates ferritin level is rising as Hb synthesis is dropping further iron therapy may be postponed.
    (d) A rising ferritin level and a drop in TSAT suggest an inflammatory condition: a source of inflammation may be sought sepsis, vascular access, surgery, recent hospitalization: further iron therapy depends on target ferritin level and clinical scenario.
    (e) Ongoing high requirements for IV iron to maintain a given ferritin level also point to ongoing blood loss.
    (f) The finding of a TSAT less than 20% coupled with a ferritin level greater than 500 μg/l poses a particularly difficult problem for clinicians. This situation may be caused by iron test variability, inflammation, or reticuloendothelial iron blockade. Evidence on the risks and benefits of IV iron therapy in these patients is not well established.

(Fig 16: **Algorithm of Anemia Management)**

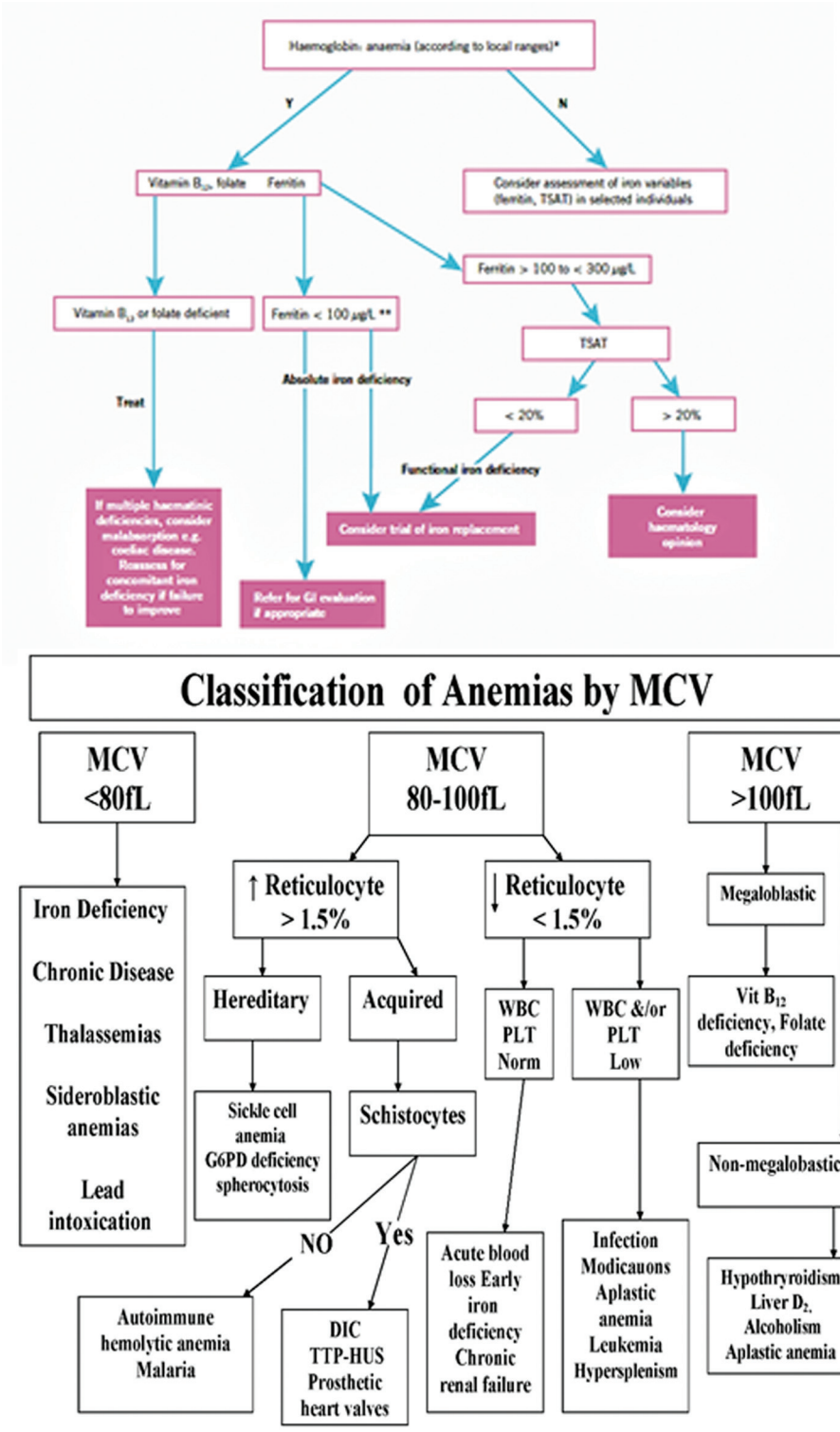
Figure 16



Algorithm for anemia management.

(Fig 17: **Classification of Anemia by MCV)**

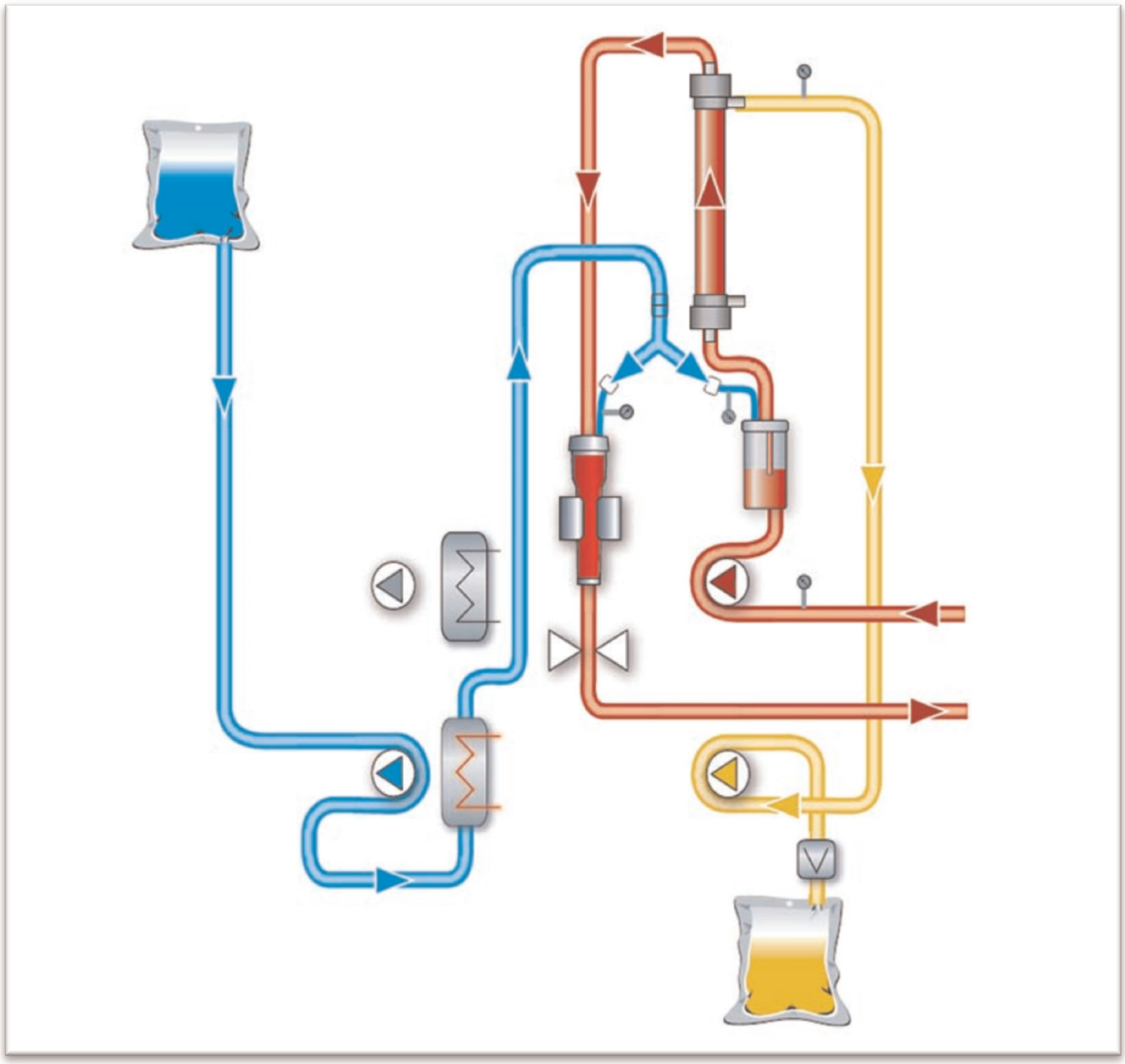
Figure 17



Classification of anemia by MCV.

Guideline V

Guidelines for Dialysis in AKI



V-Dialysis in AKI

Yasser Abdelhamid, *MD, Professor of Nephrology, Cairo University.*

Guideline (V)

Guidelines for Dialysis in AKI

(1) Initiation of Renal Replacement Therapy 'RRT':

1.1 Initiate RRT emergently when life-threatening changes in fluid, electrolyte, and acid–base balance exist.

1.2 Consider the patient clinical situation that are reversible with dialysis (such as toxicity with a dialyzable toxin) and trends of laboratory tests – rather than single BUN and creatinine thresholds alone – when making the decision to start RRT.

Goals of RRT in AKI:

(1) To maintain fluid and electrolyte, acid-base, and solute homeostasis.
(2) To allow other supportive measures (e.g., antibiotics, nutrition support)
(3) To allow removal of cytokines that augment renal injury and or hemodynamic instability.

Indications of initiation of dialysis:

(1) Severe hyperkalemia uncontrolled by medical treatment or a life-threatening hyperkalemia.
(2) Severe metabolic acidosis.
(3) Pulmonary edema.
(4) Uremic complications.
(5) Toxicity with a dialyzable toxin.

With initiation of intermittent hemodialysis, post-treatment rebound of serum potassium will be more pronounced.

There is increasing evidence that fluid overload in critical illness and AKI is associated with adverse outcomes, especially in the pediatric setting.

(2) Modality Choice in RRT in patients AKI:

Available modalities include ID, CRRT and PD.

2.1 Use continuous and intermittent RRT as complementary therapies in AKI patients.

2.2 Clinicians should be aware of the pros and cons of different RRTs, and tailor RRT on the basis of the individual and potentially changing needs of their patients.

Advantages and Disadvantages of available RRT in AKI (Table 17)

Typical Settings of available RRT in AKI (average 70 kg man) (Table 18)

	Potential setting in AKI	Advantages	Disadvantage
IHD	Hemodynamically stable	1. Rapid removal of toxins and low-molecular-weight Substances	1. Hypotension
		2. Dialysis free period	2. Dialysis induced Disequilibrium
		3. Reduced exposure to anticoagulation	
		4. Lower costs than CRRT	
CRRT	1. Hemodynamically unstable	1. Continuous removal of toxins	1. Slower clearance of toxins
	2. Patients at risk of increased intracranial pressure	2. Hemodynamic stability	2. Need for prolonged anticoagulation
		3. Easy control of fluid balance	3. Patient immobilization
		4. No treatment-induced increase of intracranial pressure	4. Hypothermia
			5. Increased costs
			6. Technically more complex
SLEDD	Hemodynamically unstable	1. Slower volume and solute removal	Slower clearance of toxins
		2. Hemodynamic stability	
		3. Dialysis free period	
		4. Reduced exposure to anticoagulation	
PD	1. Hemodynamically unstable	1. Technically simple	1. Poor clearance in hypercatabolic patients
	2. Coagulopathy	2. Hemodynamic stability	2. Protein loss
	3. Difficult access	3. No anticoagulation	3. No control of rate of fluid removal
	4. Patients at risk of increased intracranial pressure	4. No need for vascular access	4. Risk of peritonitis
	5. Under-resourced region	5. Gradual removal of toxins	5. Hyperglycemia
			6. Requires intact peritoneal cavity
			7. Impairs diaphragmatic movement, potential for respiratory problems

	SCUF	CVVH	CVVHD	CVVHDF	PD	SLEDD	IHD
Blood flow (ml/min)	100-200	150–250	150–250	150–250	N/A	100–300	200–300
Predominant principle	Convection	Convection	Diffusion Convection	Diffusion Convection	Diffusion	Diffusion	Diffusion
Ultrafiltrate (ml/h)	100–300	1500–2000	1000–1500	1000–1500	Variable	Variable	Variable
Dialysate flow (ml/h)	0	0	1000–1500	36–72	1–2 l per exchange	100–300 ml/min	300–500 ml/min
Effluent volume (l/d)	2–8	36–48	36–72	1000–1500	24–48	N/A	N/A
Replacement fluid for zero balance (ml/h)	0	1500–2000	0	1000 – 1500	0	0	0
Urea clearance (ml/min)	1–5	25–33	25–33		Variable	80–90	Variable

SCUF: slow continuous ultrafiltration. CVVH: continuous veno-veno hemofiltration. CVVHD: continuous veno-veno hemodialysis. CVVHDF: continuous veno-veno hemodiafiltration. SLEDD: sustained low efficient daily dialysis. IHD: intermittent hemodialysis. PD: peritoneal dialysis.

2.3 Continuous Renal replacement therapy (CRRT) is suggested to be used for hemodynamically unstable patients rather than standard intermittent RRT.

2.4 Continuous renal replacement therapy (CRRT) is suggested to be used rather than intermittent RRT, for AKI patients with acute brain injury or other causes of increased intracranial pressure or generalized brain edema.

2.5 SLED may also be tolerated in hemodynamically unstable patients with AKI in settings where other forms of CRRT are not available with limited data on comparative efficacy with CRRT.

2.6 IHD may worsen neurological status by compromising cerebral perfusion pressure, decrease of mean arterial pressure (dialysis-induced hypotension) and an increase of cerebral edema and intracranial pressure (dialysis disequilibrium).

2.7 Once hemodynamic stability is achieved, treatment may be switched to standard IHD.

2.8 Protocols for decreasing hemodynamic instability with intermittent RRT:

The protocol achieved better hemodynamic stability, needed fewer interventions, and induced lesser relative blood volume changes, despite higher ultrafiltration rates.

Suggested protocol:

(a) Priming the dialysis circuit with isotonic saline.
(b) Dialysate sodium concentration at 140 mEq/l.
(c) Dialysate temperature to below 37.0°C.
(d) Discontinuing vasodilator therapy.

2.9 The use of PD in AKI is mainly confined to pediatrics and in regions with limited resources. Recent developments in the technique of PD (use of flexible and cuffed catheters, automatic cycling, and continuous flow PD) have increased its potential to become an acceptable alternative to other forms of RRT in AKI.

2.9.1 Indications of PD

Bleeding diathesis.
Hemodynamic instability.
Difficulty in obtaining a vascular access.

2.9.2 Contraindications:

Extremely high catabolism.
Severe respiratory failure.
Severe ileus.
Intra-abdominal hypertension.
Recent abdominal surgery.
Diaphragmatic peritoneum-pleura connections.

2.9.3 Pediatric considerations:

(a) PD may provide the least technically challenging option for infants and small children due to small body weight and low blood volume.
(b) CRRT is increasingly used in pediatric AKI.

(3) Vascular Access in patients with AKI:

3.1 Initiating RRT in patients with AKI is suggested to be with the use of an un-cuffed non-tunneled dialysis catheter, rather than a tunneled catheter.

(1) The outer diameter varies between 11 and 14 French, larger sizes decrease the risk of inadequate blood flow.
(2) Tip of the catheter should be in a large vein, this means that the optimal length is
    (a) 12–15 cm for the right internal jugular vein.
    (b) 15–20 cm for the left internal jugular vein.
    (c) 19–24 cm for the femoral vein.
(3) In peritoneal dialysis:
(4) The Tenckhoff catheter has become the standard for PD.
(5) Blind placement has been largely replaced by surgical placement or placement guided by ultrasound/fluoroscopy, laparoscopy, or peritoneoscopy.
(6) Continuous-flow PD dictates the need for an efficient dual-lumen catheter or two separate catheters with ports separated maximally.
(7) Further modifications, including the use of swan-neck catheters, T-fluted catheters, curled intraperitoneal portions, dual cuffs, and insertion through the rectus muscle instead of the midline, have been made to reduce remaining complications such as peritonitis, exit/tunnel infection, cuff extrusion, obstruction, and dialysate leaks.

3.2 When choosing a vein for insertion of a dialysis catheter in patients with AKI, consider these preferences.

(a) First choice: right jugular vein.
(b) Second choice: femoral vein.
(c) Third choice: left jugular vein.;
(d) Last choice: subclavian vein with preference for the dominant side.

Tips in vascular catheter insertions:

(1) Catheters in the right internal jugular vein have a straight course into the right brachiocephalic vein and superior vena cava, and, therefore, the least contact with the vessel wall and least risk of thrombosis.
(2) Catheter inserted through the subclavian or the left jugular vein has one or more angulations with more risk of thrombosis.
(3) Subclavian vein may lead to central vein stenosis and jeopardize subsequent permanent access.
(4) The subclavian vein should, therefore, be considered the last choice for insertion of a dialysis catheter in patients with AKI, especially when the risk of non-recovery of kidney function is substantial.
(5) If the subclavian vein remains the only available option, preference should be given to the dominant side.
(6) Femoral catheters:
    (a) Highest risk of infection.
    (b) More dysfunction with femoral than with right jugular catheters, but significantly more dysfunction with left jugular compared to femoral catheters.
    (c) Recirculation especially with short catheters.
    (d) Reduces the patient's mobilization.
    (e) Risk for later kidney transplantation.

3.3 Using ultrasound guidance for dialysis catheter insertion is recommended.

3.4 Obtaining a chest radiograph promptly after placement and before first use of an internal jugular or subclavian dialysis catheter is recommended.

(1) The correct position of the tip of a semi rigid dialysis catheter is at the junction of the superior vena cava and the right atrium, allowing the catheter to run in parallel with the long axis of the superior vena cava.
(2) Un-cuffed, non-tunneled dialysis catheters are semi rigid. Their tip should not be in the heart, because of the risk of atrial perforation and pericardial tamponade.
(3) A position too high in the brachiocephalic vein, especially with subclavian and left-sided catheters, should also be avoided, because it allows a narrow contact between the catheter tip and the vessel wall, which may result in improper catheter function and vessel thrombosis.
(4) Tunneled catheters are usually softer and can be positioned into the right atrium.
(5) None of the radiographic landmarks (carina, right tracheobronchial angle, etc.) that are used to exclude intra-atrial tip position are 100% reliable.

Echocardiography might be another tool to confirm the correct position of the catheter.

3.5 Using topical antibiotics over the skin insertion site of a non-tunneled dialysis catheter in ICU patients with AKI requiring RRT is not suggested due to increased risk of fungal infections and antimicrobial resistance.

3.6 Using antibiotic locks for prevention of catheter-related infections of non-tunneled dialysis catheters in AKI requiring RRT is not suggested.

(1) Risk to promote fungal infections, antimicrobial resistance, and systemic toxicity.
(2) Exceptions are:
    (a) Long-term cuffed and tunneled catheters with history of multiple catheter-related bloodstream infections despite maximal adherence to aseptic technique.
    (b) Limited venous access and history of recurrent catheter-related bloodstream infection.
    (c) Patients with heightened risk of severe sequelae from a catheter-related bloodstream infection.
    (d) In pediatrics: (Table 19)

Patient size	Catheter size	Site of insertion
Neonate	Double-lumen 7 F	Femoral artery or vein
3–6 kg	Double- or triple-lumen 7 F	Jugular, subclavian or femoral
6–30 kg	Double-lumen 8 F	Jugular, subclavian or femoral
>15 kg	Double-lumen 9 F	Jugular, subclavian or femoral
>30 kg	Double-lumen 10 F or triple-lumen 12 F	Jugular, subclavian or femoral

(1) Functional CRRT circuit survival in children is favored by larger catheter size. Avoid single lumen 5 F catheters.
(2) In PD; surgically placed Tenckhoff catheters for PD induce less complications than stiffer percutaneously placed catheters.
(3) Using a more flexible catheter for percutaneous insertion may achieve a comparable catheter survival and complication rate.

(4) Proper catheter size and site of insertion in pediatric hemodialysis settings.

(4) Dialyzer Membranes for RRT in AKI:

4.1 We suggest using dialyzers with a biocompatible membrane for IHD and CRRT in patients with AKI.

4.2 Evidences are accumulating about the effectiveness of different cutoff membranes in cytokines removal in septicemia induced AKI and in other types of AKI although coming from small randomized controlled trials and observational studies.

(5) Buffer Solutions for RRT:

5.1 Using bicarbonate, rather than lactate as a buffer is suggested in dialysate and replacement fluid for RRT in patients with AKI.

5.2 Using bicarbonate, rather than lactate is recommended as a buffer in dialysate and replacement fluid for RRT in patients with AKI and circulatory shock.

5.3 Using bicarbonate, rather than lactate is suggested as a buffer in dialysate and replacement fluid for RRT in patients with AKI and liver failure and/or lactic acidemia.

5.4 It is recommended that dialysis fluids and replacement fluids in patients with AKI, at a minimum, comply with American Association of Medical Instrumentation (AAMI) standards regarding contamination with bacteria and endotoxins.

Tips for Buffer

(1) Citrate anticoagulation, and the citrate load provides an adequate supply of anionic base to control metabolic acidosis and most patients receiving citrate anticoagulation do not need an additional buffer in the dialysate or replacement fluid.
(2) Dialysate solutions for IHD are better produced on-line by the dialysis machine, by mixing specially treated municipal water with electrolytes.
(3) Bicarbonate solutions have a higher risk of bacterial contamination and the solution is unstable in the presence of calcium and magnesium. However, in recent years, bicarbonate has gained popularity because of concerns that lactate may not be rapidly metabolized in the setting of multiple-organ failure, insufficient lactate conversion will result in worsening acidosis.
(4) Use of bicarbonate as a buffer in the dialysate or replacement fluid of AKI patients results in better correction of acidosis, lower lactate levels, and improved hemodynamic tolerance. This effect is most pronounced in patients with circulatory problems and in those with liver dysfunction.

(6) Dialysis dosing in AKI

6.1 The dose of RRT to be delivered should be prescribed before starting each session of RRT.

6.2 Frequent assessment of the actual delivered dose in order to adjust the prescription is recommended.

6.3 Provide RRT to achieve the goals of electrolyte, acid-base, solute, and fluid balance that will meet the patient's needs.

(1) Calculate the actual delivered dose with consideration of the patient situation.
(2) Actual delivered dose of RRT in AKI patients is frequently smaller than the prescribed dose and even smaller than the recommended minimum for CKD patients.
(3) Limitation of Kt/V in RRT dose calculation in AKI:
    (a) AKI patients are metabolically unstable.
    (b) In AKI, urea volume of distribution appears to exceed the patient's total body-water volume.
(4) Serum urea is influenced by several extra-renal factors, such as ethnicity, age, gender, nutrition, presence of liver disease, sepsis, muscle injury, drugs, etc.
    (a) Impediments to adequate dose delivery were
(5) Hemodynamic instability.
(6) Patient size.
(7) Access problems.
(8) Technical problems.
(9) Need for patient transportation.
(10) Early filter clotting.
    (a) In CRRT the dose is calculated as effluent volume normalized by the patient's weight and procedure time as a parameter for dose evaluation.
(11) Actual effluent flow will be influenced by interruptions of CRRT.
(12) Effluent flow will exceed actual dose in cases of:
    (a) Use of predilution method of replacement.
    (b) Reductions in membrane permeability during the treatment.
(13) It is essential to check very carefully if the prescribed RRT dose is really being delivered to AKI patients. Measures taken to in case of dose inadequacy are:
    (a) Increasing filter size.
    (b) Dialysis time.
    (c) Blood flow rate.
    (d) Dialysate and or effluent Flow rate.
(14) Consider parameters other than small-solute clearance in determining a prescription of RRT dose in AKI; such as patients'
    (a) Fluid balance, acid–base and electrolyte homeostasis, and nutrition, among others,

as possible components of an optimal RRT dose.

(b) Positive fluid balance appears to be an independent risk factor for mortality in AKI patients.

6.4 Delivering a Kt/V of 3.9 per week when using intermittent or extended RRT in AKI is recommended.

No improvement in mortality or renal recovery when the dialysis dose was increased, either by increasing Kt/V above 3.9 weekly or by achieving a plasma urea target below 90 mg/dl (15 mmol/l) in AKI patients.

6.5 Delivering an effluent volume of 20–25 ml/kg/h is recommended for CRRT in AKI. This will usually require a higher prescription of effluent volume.

(1) When prescribing dialysis dosing in CRRT, consider the difference between the prescribed dose and the actual delivered dose. In CRRT, delivery usually falls substantially short of the prescribed dose.
(2) Large multicenter trials showing no benefits of increasing CRRT doses in AKI patients above effluent flows of 20–25 ml/kg/h. In clinical practice, in order to achieve a delivered dose of 20–25 ml/kg/h, it is generally necessary to prescribe in the range of 25–30 ml/kg/h, and to minimize interruptions in CRRT.
(3) In AKI and septic shock, limited data suggest that a higher dose might be beneficial in some patients.

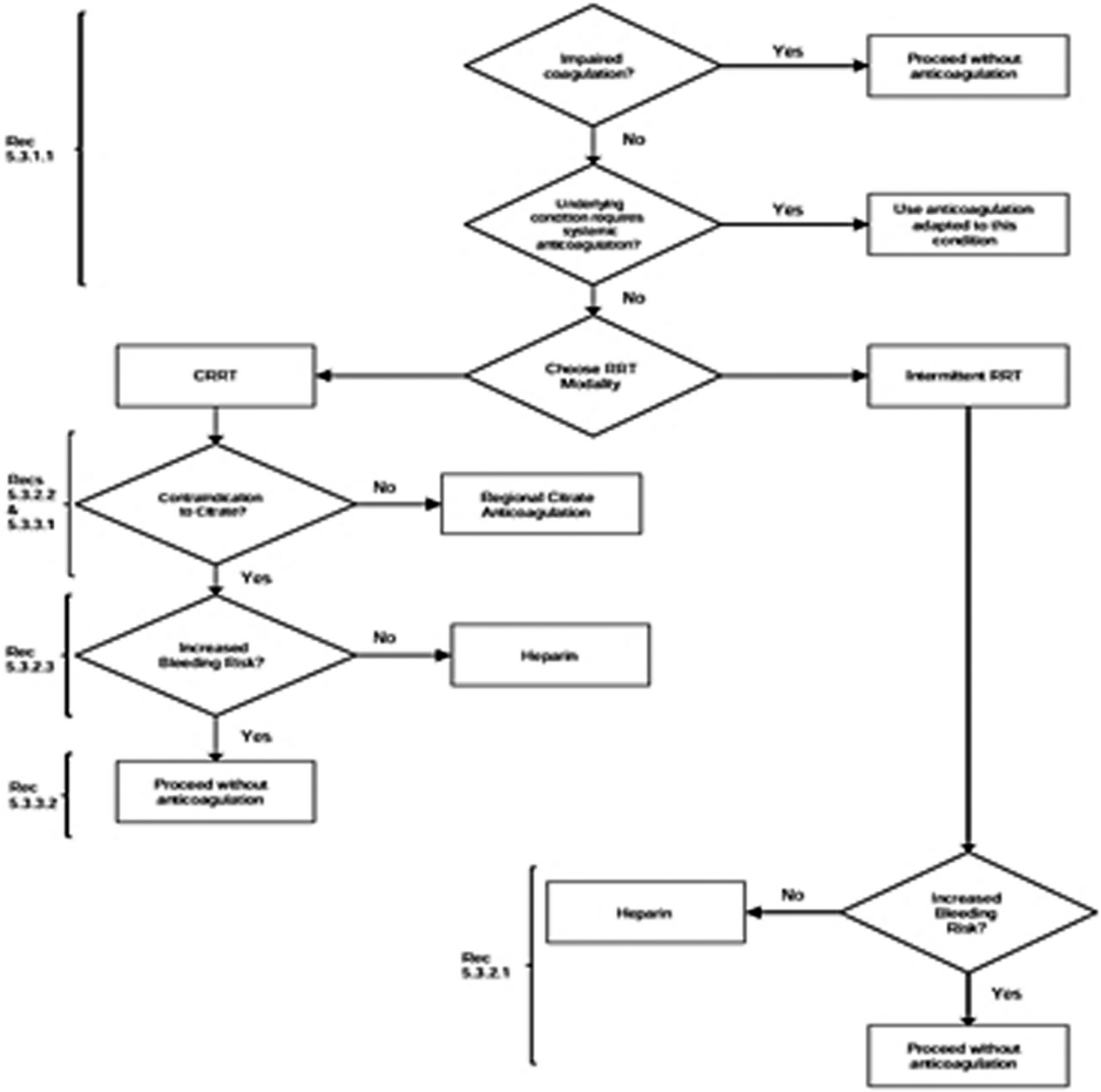
(7) Anticoagulation: (Table 20 **and** Fig 18**)**

Anticoagulant	Advantage	Disadvantage
Heparin (unfractionated)	1. Wide availability	1. Narrow therapeutic index – risk of bleeding
	2. Large experience	2. Unpredictable kinetics – monitoring required
	3. Short half-life	3. HIT
	4. Antagonist available	4. Heparin resistance
	5. Monitoring with routine tests ((aPTT or ACT)	
	6. Low costs	
LMWH	1. More predictable kinetics	1. Risk of accumulation in kidney failure
	2. Weight-based dosing possible	2. Monitoring requires nonroutine test (anti-Factor Xa)
	3. More reliable anticoagulant response	3. Different drugs not interchangeable
	4. No monitoring required	4. Incomplete reversal by protamine
	5. Single predialysis dose may be sufficient in IHD	5. In most countries more expensive than unfractionated heparin
	6. Reduced risk of HIT	
Citrate	Strict regional anticoagulation reduced bleeding risk	1. Risk of accidental overdose with potentially fatal consequences
		2. Metabolic acidosis and hypocalcemia in patients with liver cirrhosis and shock due to insufficient metabolism
		3. Other metabolic complication (acidosis, alkalosis, hypernatremia)
		4. hypocalcemia, hypercalcemia

7.1 Anticoagulation use is recommended during RRT in AKI if a patient does not have an increased bleeding risk or impaired coagulation and is not already receiving systemic anticoagulation.

(1) Patients with impaired coagulation [e.g. thrombocytopenia, or prolonged prothrombin time or activated partial thromboplastin time (aPTT)] may not benefit from additional anticoagulation for RRT.
(2) No specific cut-off points have been determined for platelet count, aPTT, INR, fibrinogen, or other coagulation factors that would indicate the possibility to perform RRT without anticoagulation.
(3) Prolonged clotting times can also point to a consumptive coagulopathy based on the presence of an activated coagulation. In these patients, frequent filter clotting will occur and necessitate use of some form of anticoagulation.
(4) Anticoagulation free strategies:
   (a) Good functioning vascular access.
   (b) Reduction of blood viscosity and hemoconcentration by saline flushes.
   (c) Predilution method of replacement.
   (d) High blood flow rates.
   (e) Diffusive treatment.
   (f) Reduction of blood-air contact in the bubble trap.
   (g) Assuring prompt reaction to alarms.
(5) Patients receiving systemic anticoagulation will not require additional anticoagulation for RRT; however, this should be assessed on a case-by-case basis.

Figure 18



Approach for CRRT anticoagulation.

(Fig 18 **Approach for Anticoagulation in CRRT**)

(Table 20 **Anticoagulation in CRRT**)

Anticoagulant drugs in AKI:

Heparin

– In patients with AKI, the dose of heparin for IHD and the target aPTT should be individualized according to the presence or absence of coagulation abnormalities and/or risk of bleeding.

– Monitoring should also include aPTT (unfractionated heparin) and platelet count (allowing timely detection of HIT).

– The American College of Chest Physicians (ACCP) guidelines for antithrombotic and thrombolytic therapy suggest using unfractionated instead of low-molecular-weight heparin in patients with severe renal insufficiency (CrCl <30 ml/min) who require therapeutic anticoagulation, or to reduce the dose of low molecular-weight heparin by 50%.

– The doses of low molecular-weight heparin that are required for IHD are lower than those required for therapeutic anticoagulation.

– Dose reduction may also be required in patients receiving daily dialysis, which increases the risk of accumulation.

– If DVT prophylaxis is required, scheduling this prophylactic (or a slightly higher) dose at the beginning of the dialysis session.

– Comparison of unfractionated heparin with LMWH revealed no firm recommendations.

Citrate:

– Used in anticoagulation during CRRT in patients that do not have shock or severe liver failure, and in centers that have an established protocol for citrate anticoagulation.

– A major contra-indication for the use of citrate anticoagulation is severely impaired liver function or shock with muscle hypoperfusion, both representing a risk of citrate accumulation.

7.2 For patients with AKI and increased bleeding risk who are not receiving anticoagulation, the following is suggested during RRT:

(1) Using regional citrate anticoagulation, rather than no anticoagulation, during CRRT in a patient without contraindications for citrate.
(2) Avoiding regional heparinization during CRRT in a patient with increased risk of bleeding:
   (a) Heparin has a much longer half-life than protamine, risk of rebound effect.
   (b) Exposes the patient to the side-effects of both heparin (mainly the risk of HIT) and protamine (anaphylaxis, platelet dysfunction, hypotension, and pulmonary vasoconstriction with right ventricular failure).

7.3 In a patient with HIT who does not have severe liver failure, using argatroban rather than other thrombin or Factor Xa inhibitors during RRT is suggested.

In a patient with HIT who does not have severe liver failure, we suggest using argatroban rather than other thrombin or Factor Xa inhibitors during RRT.

Heparin Induced Thrombocytopenia (HIT):

(1) Suspected in patients with thrombocytopenia with or without thrombosis.
(2) In patients with AKI undergoing CRRT, the diagnosis should also be suspected in patients with repeated premature filter clotting.
(3) Predicted by the so-called 4 T score:
   (a) Degree of thrombocytopenia.
   (b) Timing of onset of the fall in platelet count.
   (c) Presence of thrombosis or acute systemic symptoms.
   (d) Presence of other etiologies of thrombocytopenia.

Treatment:

(a) Heparins have to be stopped, including any 'heparin lock' solutions for dialysis or other catheters.
(b) Use of therapeutic doses of an alternative non-heparin anticoagulant in patients with strong suspicion of HIT (Direct thrombin inhibitors lepirudin, argatroban, or bivaluridin, or the antithrombin-dependent Factor Xa inhibitors, danaparoid or fondaparinix).

In Children:

Heparin-based and citrate-based anticoagulation protocols have been shown to confer equitable filter survival in pediatric CRRT, and the use of either is clearly supported over the use of no anticoagulation schemes.

(8) Termination of RRT:

8.1 Discontinue RRT when it is no longer required, either because intrinsic kidney function has recovered to the point that it is adequate to meet patient needs, or because RRT is no longer consistent with the goals of care (no clear indication to continue RRT).

Independent predictors for restarting RRT within 30 days were:

(1) Longer duration of RRT.
(2) Higher Sequential Organ Failure Assessment score.
(3) Oliguria.
(4) Age more than 65 years.

The process of stopping RRT may consist of simple discontinuation of RRT, or may include a change in the modality, frequency, or duration of RRT.

8.2 Diuretics were not suggested to be used to enhance kidney function recovery, or to reduce the duration or frequency of RRT.

(a) There were no differences in need for repeated CVVH, or renal recovery during ICU or hospital stay between patients received diuretics and patients who did not.
(b) Diuretics may improve urine volume after RRT, but do not appear to have any significant benefit in reducing the need for RRT or promoting renal recovery from AKI.

VI. Infection Control Measures

A. Quick guide to implement strategies for Infection Control in Hemodialysis unit

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(1) Hand Hygiene

Hand hygiene is an important measure for preventing vascular access-related infections, and dialysis facilities should ensure the availability of easily accessible handwashing sinks and alcohol-based hand sanitizers.

1.1 Opportunities for hand hygiene include: (Figs. 19–21)

(1) Before touching a patient.
(2) Before aseptic procedures.

VI. Infection Control Measures

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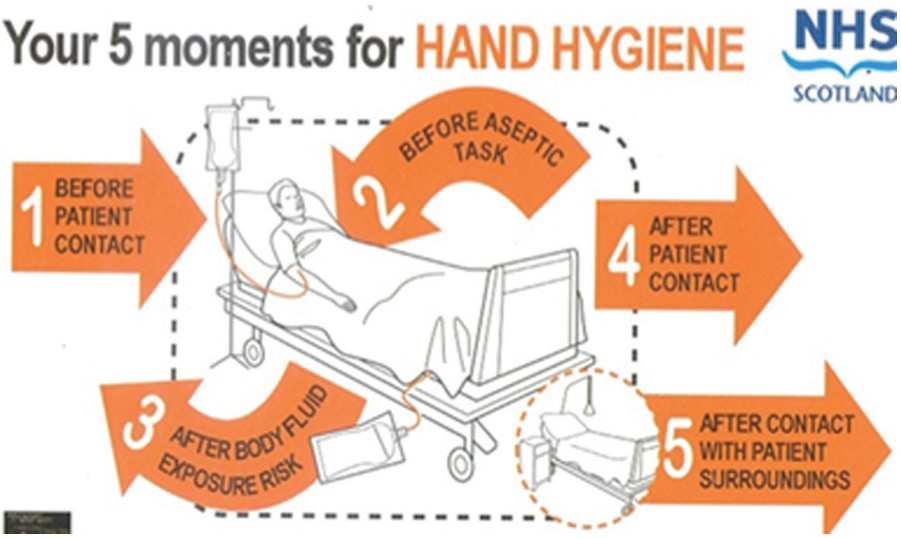
(3) After body fluid exposure risk.
(4) After touching a patient.
(5) After touching patient surroundings.

1.2 Social hand washing should take at least 30 s:

(1) Wet hands under running warm water.
(2) Dispense one dose of soap into cupped hands.

Figure 19



Hand hygiene, WHO 5 moments –Opportunities for hand hygiene.

Figure 20

Hand Washing Technique.

Figure 21

How to Hand Rub.

(3) Rub hands palm to palm.
(4) Right palm over the back of the other hand with interlaced fingers and vice versa.
(5) Palm to palm with fingers interlaced.
(6) Back of fingers to opposing palms with fingers interlocked.
(7) Rotational rubbing of left thumb clasped in right palm and vice versa.
(8) Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa.
(9) Rinse hands with warm water.
(10) Dry thoroughly with paper towel (Rationale 1). Cloth towels must not be used (Rationale 2). Warm air hand dryers may be used in non-clinical areas (Rationale 3).
(11) Turn off taps using a 'hands-free' technique (e.g. elbows). Where this is not possible, the paper towel used to dry the hands can be used to turn off the tap (Rationale 4).
(12) Dispose of the paper towel without re-contaminating hands. Do not touch bin lid with hands (Rationale 5).

1.3 Alcohol gel/foam:

This can be used on visibly clean hands as an alternative to a social hand wash.

(1) Will not remove dirt and organic matter and can only be used when hands are not visibly soiled.
(2) Should not be used prior to handling medical gas cylinders because of the risk of ignition.
(3) Is NOT effective against Clostridium difficile and Norovirus. When caring for a patient with either of these organisms, hands must be washed with soap and water.
(4) Soap and alcohol-based hand rub should not be used concomitantly.
(5) When applying alcohol hand rub leave to dry naturally on the skin.
(6) Hands should be washed with soap and water after several consecutive applications of hand rub (Rationale 6).

1.4 When should a surgical hand wash be performed?

Before all surgical/invasive procedures.

1.5 What should be used for performing a surgical hand wash?

An approved antiseptic detergent (e.g. 4% Chlorhexidine gluconate or 7.5% Povidone iodine).

1.6 How should a surgical hand wash be performed?

(a) When performing a surgical hand wash, the level of the hands should always remain above the elbows (Rationale 7).
(b) Always use sensor or elbow operated taps (Rationale 4).
(c) Apply antiseptic detergent to the hands and wrists and wash for at least 1 min up to the elbow.
(d) A sterile brush may be used for the first application of the day, but continual use is inadvisable.
(e) Using a pre-packed sterile brush, clean under the nails only of both hands.
(f) Rinse thoroughly.
(g) Apply a second application of antiseptic detergent and wash hands and two thirds of the forearms with either Povidone iodine for at least 1 min, or Chlorhexidine gluconate for at least 2 min.
(h) Rinse thoroughly.
(i) One sterile towel should be used to blot dry the first hand and arm and another sterile towel for the second hand and arm (Rationale 8).

2. Central Line Bundle Compliance

The central line bundle is a group of evidence-based interventions for patients with intravascular central catheters that, when implemented together, result in better outcomes than when implemented individually.

2.1 Key component

(1) Hand hygiene.
(2) Maximal barrier precautions (both for the patient and the inserter) when placing a central line.
(3) Skin antisepsis.
(4) Optimal catheter site selection.
(5) Assessment of line necessity with prompt removal of unnecessary line.
(6) Use maximal sterile barrier precautions (i.e. mask, cap, gown, sterile gloves, and sterile full body drape).
(7) Choose the best insertion site to minimize infections and noninfectious complications based on individual patient characteristics. Avoid femoral site in obese adult patients.
(8) Prepare clean skin site with a chlorhexidine gluconate (CHG) solution (2% in 70% alcohol is recommended) prior to catheter insertion and dressing changes. For patients with sensitivities or suspected contraindications to CHG (i.e. allergy, hypersensitivity), povidone–iodine can be used as an alternative. Apply using a back-and-forth friction scrub for at least 30 s, according to manufacturers' instructions.
(9) Place a sterile gauze dressing or a sterile, transparent, semipermeable dressing over the insertion site.
(10) For patients 18 years of age or older, use a chlorhexidine impregnated dressing with an FDA cleared label that specifies a clinical indication for reducing CLABSI for short term non-tunneled catheters unless the facility is demonstrating success at preventing CLABSI with baseline prevention practices.

2.2 Handle and maintain central lines appropriately

(1) Comply with hand hygiene requirements.
(2) Scrub the access port or hub with friction immediately prior to each use with an appropriate antiseptic (chlorhexidine, povidone iodine, an iodophor, or 70% alcohol).
(3) Use only sterile devices to access catheters.
(4) Immediately replace dressings that are wet, soiled, or dislodged.
(5) Perform routine dressing changes using aseptic technique with clean or sterile gloves.
(6) Change gauze dressings at least every 2 days or semipermeable dressings at least every 7 days.
(7) For patients 18 years of age or older, use a chlorhexidine impregnated dressing with an FDA cleared label that specifies a clinical indication for reducing CLABSI for short-term non-tunneled catheters unless the facility is demonstrating success at preventing CLABSI with baseline prevention practices.
(8) Change administrations sets for continuous infusions no more frequently than every 4 days, but at least every 7 days.
(9) Promptly remove unnecessary central lines
(10) Perform daily audits to assess whether each central line is still needed.

3. Selection of Catheters and Sites

(1) Catheters should be used only when other options (fistulas then prosthetic grafts) are not available.
(2) For acute dialysis (<7 days), use short-term catheters.
(3) Long-term catheters or dialysis port catheter systems are preferred for permanent access. Tunneled catheters are suggested for temporary access more than 3 weeks and during maturation of a primary AV fistula.

(4) Patients who have exhausted all other access options may require permanent access via Tunneled cuffed catheters.
(5) Avoid placing long-term catheters on the same side as a maturing AV access.
    (a) The right internal jugular vein is the preferred site.
    (b) Catheters should not be placed in the subclavian vessels because of the risk for stenosis.
(6) At each HD session, experienced personnel should examine the exit site/port cannulation site for proper position and absence of infection before opening and accessing the site.
(7) Maintain catheter lumens as sterile.
    (a) Never allow the lumen and tip to remain open to air.
    (b) Place a cap or syringe on/within the lumen while maintaining a clean field under the catheter connectors.
    (c) Clean gowns must be changed between patients.
    (d) Monitor catheter site visibly and check for inflammation during dressing changes.
(8) Antibiotic/Antiseptic Ointments and Locks
    (a) Use povidone iodine/bacitracin/neomycin/polymyxin B ointment at the hemodialysis catheter exit site after catheter insertion, and at the end of each treatment, only when the manufacturer indicates it does not interact with the catheter material.
    (b) For patients with a history of recurrent *S. aureus* CR-BSI, use povidone iodine or polysporin ointment at the insertion site.
    (c) Mupirocin is contraindicated due to the risk of developing mupirocin resistance, as well as damage to polyurethane catheter.
    (d) To prevent potential development of organism resistance from leakage of the lock solution into the bloodstream, antimicrobial locks should only be used as a preventative strategy7:
        (1) When there is limited venous access and a history of recurrent infection.
        (2) In patients at heightened risk for severe sequelae from an infection.

4. Catheter Connection and Disconnection Steps:

Connection Steps

(1) Perform hand hygiene and don new clean gloves.
(2) Clamp the catheter (Note: Always clamp the catheter before removing the cap. Never leave an uncapped catheter unattended).
(3) Disinfect the hub with caps removed using an appropriate antiseptic (see notes).
    (a) (Optional) Prior to cap removal, disinfect the caps and the part of the hub that is accessible and discard the antiseptic pad (i.e., use a separate antiseptic pad for the next step).
    (b) Remove the caps and disinfect the hub with a new antiseptic pad for each hub. Scrub the sides (threads) and end of the hub thoroughly with friction, making sure to remove any residue (e.g. blood).
    (c) Using the same antiseptic pad, apply antiseptic with friction to the catheter, moving from the hub at least several centimeters towards the body. Hold the limb while allowing the antiseptic to dry.
    (d) Use a separate antiseptic pad for each hub/catheter limb. Leave hubs 'open' (i.e. uncapped and disconnected) for the shortest time possible.
(4) Always handle the catheter hubs aseptically. Once disinfected, do not allow the catheter hubs to touch nonsterile surfaces.
(5) Attach sterile syringe, unclamp the catheter, withdraw blood, and flush per facility protocol.
(6) Repeat for other limb (this might occur in parallel).
(7) Connect the ends of the blood lines to the catheter aseptically.
(8) Remove gloves and perform hand hygiene.

Disconnection Steps:

(1) Perform hand hygiene and don new clean gloves.
(2) Clamp the catheter (Note: Always clamp the catheter before disconnecting. Never leave an uncapped catheter unattended).
(3) Disinfect the catheter hub before applying the new cap using an appropriate antiseptic (see notes).
    (a) (Optional) Disinfect the connection prior to disconnection. If this is done, use a separate antiseptic pad for the subsequent disinfection of the hub.
    (b) Disconnect the blood line from the catheter and disinfect the hub with a new antiseptic pad. Scrub the sides (threads) and end of the hub thoroughly with friction, making sure to remove any residue (e.g. blood).
    (c) Use a separate antiseptic pad for each hub. Leave hubs 'open' (i.e. uncapped and disconnected) for the shortest time possible.
(4) Always handle the catheter hubs aseptically. Once disinfected, do not allow the catheter hubs to touch nonsterile surfaces. Hold the catheter until the antiseptic has dried.

(5) Attach the new sterile caps to the catheter aseptically. Use caution if tape is used to secure caps to the catheter (see notes).
(6) Ensure that catheter is still clamped.
(7) Remove gloves and perform hand hygiene.

5. Basic Steps in Fistula/Graft Care

Cannulation Procedure

(1) Wash the site.
(2) Perform hand hygiene.
(3) Put on a new, clean pair of gloves.
(4) Wear proper face protection.
(5) Apply skin antiseptic and allow it to dry.
(6) Insert needle using aseptic technique.
(7) Remove gloves and perform hand hygiene.

6. Aseptic Technique

(1) The patient's skin is disinfected with an appropriate antiseptic before injection or cannulation.
(2) Preparation and dilution of drugs' vials is only done by ready-made sterile water. Needles and syringes including prefilled syringes and cartridge devices such as insulin pens are used for only one patient.
(3) The rubber self-sealed cap on a medication vial is disinfected with alcohol prior to piercing. IV solution bottles are only accessed through the self-sealed rubber cap.
(4) Multidose medication vials are accessed with a new needle and a new syringe, even when obtaining additional doses for the same patient.
(5) All items in patient zones used for patient care only and any remaining items after patient discharge are considered contaminated even in their wrapping.
(6) Items are stored 20–25 cm off the floor to allow cleaning underneath.
(7) Sterile and clean items completely separated from personal items, food and drinks.
(8) Separate clean area is available for preparing medications.

7. Environmental Disinfection

There is a cleaning schedule and is applied to the followings:

(1) Housekeeping surfaces (e.g. floors, walls, and sinks) cleaned with MOH approved detergent/ disinfectant using double/ or triple bucket technique or scrubbing machines.
(2) Housekeeping equipment is kept clean and dry after use.
(3) Health care personnel demonstrate appropriate technique for management of blood and/or body fluids.
(4) Appropriate PPE, for example gloves, masks, gowns and protective eyewear, worn by housekeepers during their routine activities.
(5) Nurses are responsible for cleaning of all environmental surfaces in patient areas except floors, walls, ceiling and bathrooms.
(6) Dialysis machine, bed, chair, and supply tray (including tourniquet, antiseptics and blood pressure cuff and stethoscopes) receive adequate cleaning and disinfection between patients.
(7) Disinfect all external surfaces with 500 ppm sodium hypochlorite or comparable disinfectant after every patient.

7. Waste Management

(1) All types of waste containers are available in sufficient number and placed in easily accessible sites and away from traffic.
(2) Sharp items (e.g. needles, scalpel blades and broken metal instruments) are placed in an appropriate sharp's container (puncture resistant, color-coded, and leak-proof).
(3) Used needles are not manipulated or recapped and are promptly disposed into sharp containers.
(4) Staff sticks to the approved policies of proper medical waste segregation (no dangerous medical waste or sharps are observed outside specified containers).
(5) Medical waste bags and sharp boxes are ¾ filled.
(6) Occupational Health All hemodialysis unit employees are screened for Hepatitis B and Hepatitis C.

8. Laundry

(1) Contaminated linen is collected with minimum agitation in special color-coded and waterproof laundry bags.
(2) Linen carts are covered and not overfilled.

9. Isolation

(1) Contact isolation precautions are initiated for patients infected or colonized with multidrug-resistant organisms.
(2) All patients in the dialysis unit should be screened for hepatitis B surface antigen (HBsAg) and anti-HBsAg, HCV Ab and HIV when they join the unit, to determine their serologic status.
(3) Isolation of HBsAg-positive patients in a designated or separate room for treatment with

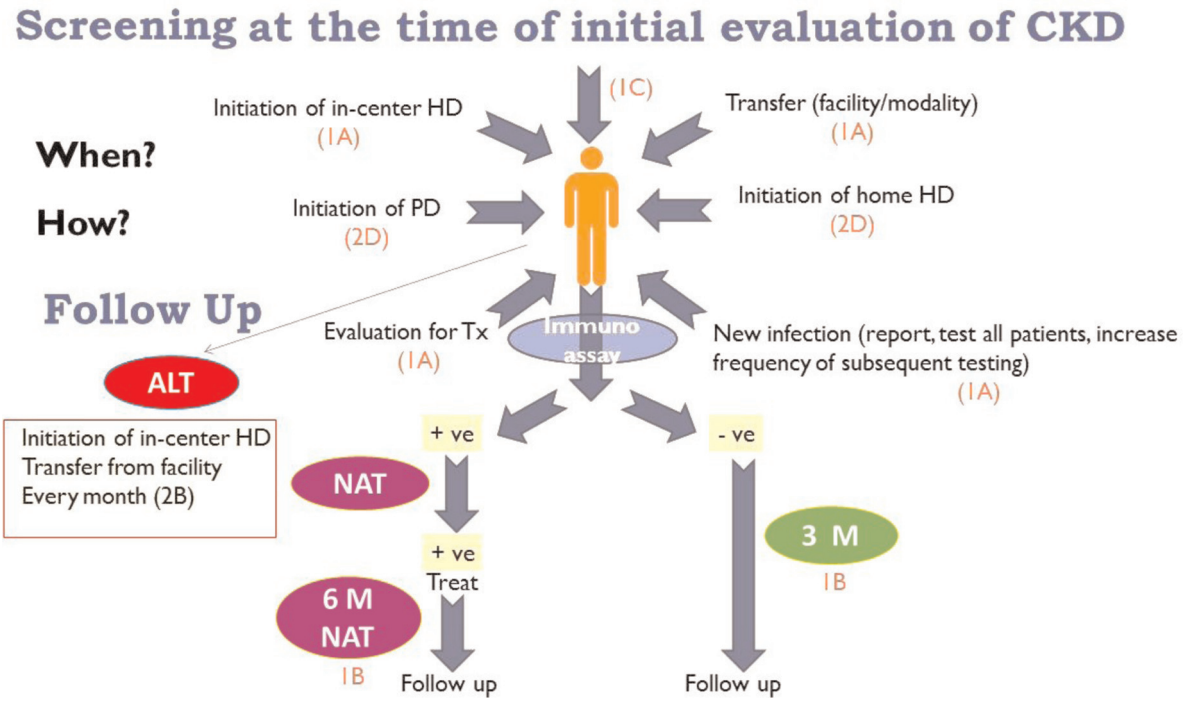
dedicated machines, equipment, instruments, supplies, and medications.
(4) HCV Ab negative patients are screened quarterly (every 3 month) for anti-HCV.
(5) Isolation of HCV Ab positive patients in a designated or separate room for treatment with dedicated machines, equipment, instruments, supplies, and medications.

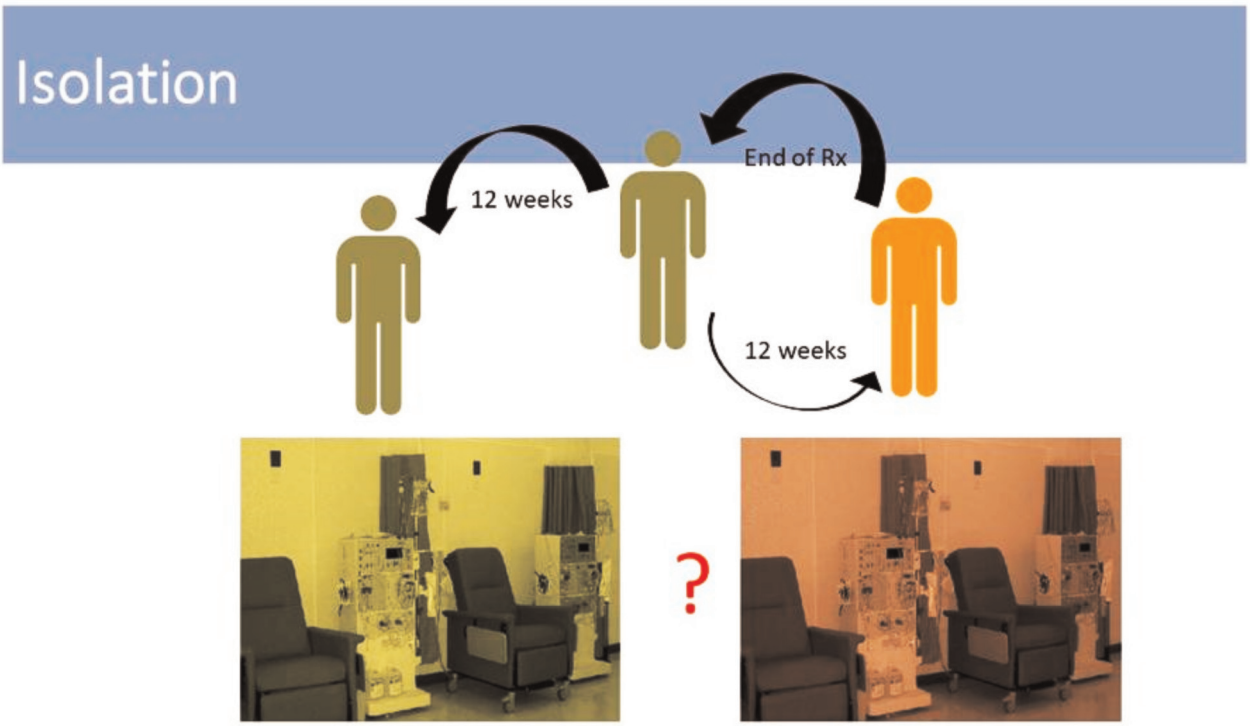
10. Storage Area

(1) Clean and dry (temperature and humidity must be controlled).
(2) Away from air vents and well ventilated.
(3) Storage shelves are18 inches from the ceiling, 8–10 inches from the floor, and 2 inches from the outside wall.
(4) Storage shelves made from easily cleanable material (not woody or Cardboard).
(5) Sterile and clean items completely separated from personal items and foods and drinks.
(6) Rotate supplies on a first-in-first-out basis so as to avoid the use of expired items.
(7) Items not kept in original cardboard boxes Clean and dry.

Egyptian Protocol in hemodialysis units:

(1) All patients in the dialysis unit should be screened for Hepatitis B surface antigen (HBsAg), Hepatitis C Virus (HCV Ab) and HIV Ab when they are recently joining the unit, or transferred between units, to determine their serologic status.
(2) HBsAg-positive patients should be isolated in a designated or separate room for treatment with dedicated machines, equipment, instruments, supplies, and medications.
(3) HCV Ab negative patients are screened monthly for ALT and every 3 months for HCV Ab test.
(4) HCV Ab +ve patients should undergo nucleic acid testing (NAT).
(5) HCV PCR +ve patients should be isolated in a designated or separate room for treatment with dedicated machines, equipment, instruments, supplies, and medications.
(6) HCV Ab +ve, PCR +ve, patients should be treated not only to improve survival, reduce morbidity and prepare for transplantation, but also to eliminate an important focus of dissemination.
(7) HCV Ab +ve patients should only be followed by Nucleic acid testing (NAT).
(8) After successful treatment, HCV Ab +ve, PCR –ve patients should be isolated in a separate room.
(9) Nucleic acid testing (NAT) is done after 3 months, if still –ve, the patient can be transferred to the HCV –ve room.
(10) HCV Ab +ve patients are followed up/6 months by nucleic acid testing (NAT).
(11) HCV Ab +ve, patients should never be followed up by antibody testing.
(12) Should an HCV Ab +ve, PCR –ve patient becomes PCR +ve, he should be isolated, and investigation done to determine the source of infection, same applies to seroconversion.





This Guideline is published according to the following International Guidelines and references

The Egyptian Guideline is in accordance to the following for further Readings:

(1) **UK Renal Association**, Clinical Practice Guidelines, 4th Edition, 2007.
MODULE 2: Hemodialysis, and, **The Renal Association Clinical Practice Guidelines**, July 2019.

(2) **NKF-KDOQI Clinical Practice Guideline for Hemodialysis Adequacy**: Update, 2015.

(3) **European Best Practice Guidelines EBPG on haemodialysis Strategies**, 2007.

(4) **European Best practice Guidelines EBPG guideline on haemodynamic instability**, 2007.

(5) **Blood pressure targets for hemodialysis patients Review**, Jeffrey M. Turner1 and Aldo J. Peixoto, kidney International 92, 816–823, 2017.

(6) **European Best Practice Guidelines EBPG guideline on Nutrition**, 2007.

(7) **Standard Operating Procedures for the Management of a Patient Hemodialysis care**. University Hospital Birmingham National Health Service (NHS) version 1, 2014.

(8) **Japanese Society for Dialysis Therapy Clinical Guideline for 'Maintenance Hemodialysis: Hemodialysis Prescriptions'** Yuzo Watanabe etal, *Therapeutic Apheresis and Dialysis* 67–92 19(Supplement 1), 2015.

(9) **NKF-KDOQI Clinical Practice Guideline for Vascular Access**, 2006.

(10) **NKF-KDOQI Clinical Practice Guideline Update for the Diagnosis, Evaluation, Prevention, and Treatment of Chronic Kidney Disease–Mineral and Bone Disorder** (CKD-MBD), 2017.

(11) **Management of Osteoporosis in CKD**, Khairallah P1, Nickolas T, Clin J Am Soc Nephrol. Jun 7;13(6):962-969, 2018.

(12) **NKF-KDOQI Clinical Practice Guideline for Anemia in Chronic Kidney Disease:** Update of Hemoglobin Target, 2007 and KDOQI US Commentary on the KDIGO Clinical Practice Guideline for Anemia in CKD, 2012.

(13) **NKF-KDIGO Clinical Practice Guideline for Acute Kidney Injury**, Volume 2, Issue 1, March 2012.

(14) **NKF-KDIGO 2018 Clinical Practice Guideline for the Prevention, Diagnosis, Evaluation, and Treatment of Hepatitis C in Chronic Kidney Disease**, Volume 8, | Issue 3, October 2018.