Fluid Management

*Looking beyond “You’re gaining too much fluid”*

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Las Vegas

*Elaine Go, RN, NP, MSN*

Advanced Practice Nurse
St. Joseph Hospital Renal Center
Orange, California

Nephrology Nurse Practitioner
Nephrology Specialists Medical Group
Orange, California
Objectives

- Discuss causes of large fluid gains in many hemodialysis patients
- Discuss strategies in reducing inter-dialytic weight gain in hemodialysis patients
- Discuss fluid management techniques during hemodialysis
Nephron – basic functional unit

Approximately 1 million nephrons in each kidney

Source: www.jama.com
Functions of the Kidney

- **Primary purpose** - regulate composition of blood and other body fluids as blood circulates through the kidneys
  1. Removes end products of metabolism – urea, creatinine, uric acid
  2. *Regulates vascular and extra vascular volume by controlling the amount of water excreted*
  3. Regulates acid base balance
  4. Electrolyte regulation
  5. Regulates blood pressure through production of renin
  6. RBC synthesis – erythropoietin
  7. Synthesizes vitamin D to its active form
Chronic Kidney Disease

1. Progressive
2. Irreversible loss of kidney function

Occurs over varying periods of time in varying stages.
Chronic Kidney Disease

**What do we know?**

- 26 million Americans have it (1 in 9) and is a public health problem
- It should be detected early and treated early
- CVD more often leads to death than dialysis
- If detected and treated early will improve patient outcomes
- Patients who do progress to CKD Stage 5 will be in better shape for dialysis
Diabetes: The Most Common Cause of ESRD

Primary Diagnosis for Patients Who Start Dialysis

- **Diabetes**: 44.3%
- **Hypertension**: 27%
- **Glomerulonephritis**: 13%
- **Other**: 10%

No. of patients (thousands) vs. Time (years)

- **1984**: 243,524
- **1996**: 281,355
- **2000**: Projected 281,355
- **2008**: Projected 520,240

**r^2 = 99.8%**

<table>
<thead>
<tr>
<th>BP Classification</th>
<th>Systolic BP, mm Hg*</th>
<th>Diastolic BP, mm Hg*</th>
<th>Lifestyle Modification</th>
<th>Management*</th>
<th>Initial Drug Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt;120 and</td>
<td>&lt;80</td>
<td>Encourage</td>
<td></td>
<td>Drug(s) for the compelling indications‡</td>
</tr>
<tr>
<td>Prehypertension</td>
<td>120-139 or</td>
<td>80-89</td>
<td>Yes</td>
<td>No antihypertensive drug indicated</td>
<td>Drug(s) for the compelling indications‡</td>
</tr>
<tr>
<td>Stage 1 hypertension</td>
<td>140-159 or</td>
<td>90-99</td>
<td>Yes</td>
<td>Thiazide-type diuretics for most; may consider ACE inhibitor, ARB, β-blocker, CCB, or combination</td>
<td>Drug(s) for the compelling indications Other antihypertensive drugs (diuretics, ACE inhibitor, ARB, β-blocker, CCB) as needed</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
<td>≥160 or</td>
<td>≥100</td>
<td>Yes</td>
<td>2-Drug combination for most (usually thiazide-type diuretic and ACE inhibitor or ARB or β-blocker or CCB)§</td>
<td>Drug(s) for the compelling indications Other antihypertensive drugs (diuretics, ACE inhibitor, ARB, β-blocker, CCB) as needed</td>
</tr>
</tbody>
</table>

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin-receptor blocker; BP, blood pressure; CCB, calcium channel blocker.
*Treatment determined by highest BP category.
†See Table 6.
‡Treat patients with chronic kidney disease or diabetes to BP goal of less than 130/80 mm Hg.
§Initial combined therapy should be used cautiously in those at risk for orthostatic hypotension.
NORMAL CAPILLARIES OF A GLOMERULUS, THE SMALLEST FUNCTIONAL FILTRATION UNIT OF THE KIDNEY. THE BLOOD FLOWS EASILY THROUGH THE GLOMERULAR CAPILLARIES.

GLOMERULUS WITH HYPERTENSIVE DAMAGE: THE BOWMAN'S CAPSULE AND THE GLOMERULAR BASEMENT MEMBRANE THICKENS WHILE EXTRACELLULAR MATRIX PROTEINS, SUCH AS COLLAGEN, EXPAND. THE GLOMERULAR TUFT SHRINKS AS CAPILLARY WALLS WRINKLE AND SCAR, LEAVING THE GLOMERULUS UNABLE TO FUNCTION.
# New ICD-9 Codes for Chronic Kidney Disease

**Find it, Stage it, Code it, Act!**

<table>
<thead>
<tr>
<th>Stage</th>
<th>ICD-9-CM Code</th>
<th>Description</th>
<th>GFR (mL/min/1.73 m²)</th>
<th>Classification of CKD by Severity</th>
<th>Clinical Presentations*</th>
<th>Classification by Treatment**</th>
<th>Action*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>585.1 Chronic kidney disease, Stage I</td>
<td>Kidney damage with normal or ↑ GFR</td>
<td>≥ 90</td>
<td>Markers of damage (Nephrotic syndrome, Nephritic syndrome, Tubular syndromes, Urinary tract symptoms, Asymptomatic urinalysis abnormalities, Arteriosclerotic radiologic abnormalities, Hypertension due to kidney disease)</td>
<td>T</td>
<td>Diagnosis and treatment, Treatment of comorbid conditions, Slowing progression, CVD risk reduction</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>585.2 Chronic kidney disease, Stage II (mild)</td>
<td>Kidney damage with mild ↓ GFR</td>
<td>60–89</td>
<td>Mild complications</td>
<td>T</td>
<td>Estimating progression</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>585.3 Chronic kidney disease, Stage III (moderate)</td>
<td>Moderate ↓ GFR</td>
<td>30–59</td>
<td>Moderate complications</td>
<td>T</td>
<td>Evaluating and treating complications</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>585.4 Chronic kidney disease, Stage IV (severe)</td>
<td>Severe ↓ GFR</td>
<td>15–29</td>
<td>Severe complications</td>
<td>T</td>
<td>Preparation for kidney replacement therapy</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>585.5 Chronic kidney disease, Stage V</td>
<td>Kidney failure</td>
<td>&lt;15 (or dialysis)</td>
<td>Uremia, Cardiovascular disease</td>
<td>T</td>
<td>Replacement (if uremia present)</td>
<td></td>
</tr>
</tbody>
</table>


*Includes presentations and actions from preceding stages. Chronic kidney disease is defined as either kidney damage or GFR <60 mL/min/1.73 m² for ≥3 months. Kidney damage is defined as pathologic abnormalities or markers of damage, including abnormalities in blood or urine tests or imaging studies.

**Classification T is added for all kidney transplant recipients, at any level of GFR (KDQI stages 1-5). Classification T is added for KDQI stage 3 patients treated by dialysis.

### Additional Codes

- **585 Chronic kidney disease**
  - Use additional codes to identify kidney transplant status, if applicable (V42.0).
- **585.9 Chronic kidney disease, unspecified**
  - Chronic renal disease
  - Chronic renal failure NOS
  - Chronic renal insufficiency

- **285.2 Anemia in chronic illness**
  - 285.21 Anemia in chronic kidney disease
  - Anemia in end stage renal disease

- **403 Hypertensive kidney disease (see note below)**
  - Use additional code to identify the stage of chronic kidney disease (585.1-585.6), if known
  - The following fifth-digit subclassification is for use with category 403:
    - 0 without chronic kidney disease
    - 1 with chronic kidney disease

- **404 Hypertensive heart and kidney disease (see note below)**
  - Use additional code to specify type of heart failure (I20.0-I22.43), if known
  - Use additional code to identify the stage of chronic kidney disease (585.1-585.6), if known
  - The following fifth-digit subclassification is for use with category 404:
    - 0 without heart failure or chronic kidney disease
    - 2 with chronic kidney disease
    - 3 with heart failure and chronic kidney disease

### Note:

Following the finalization of the titles it has been determined that since the codes under category 585 include the entire continuum of CKD it will be necessary to modify the titles for the fifth-digit in categories 403 and 404 again to reflect this. All patients with hypertensive kidney disease have both hypertension and some stage of CKD, so the current code titles for fifth-digit 0 for categories 403 and 404 are invalid. Until new titles become effective only fifth-digit 1 for category 403 should be used. For category 404 only fifth-digits 2 and 3 should be used for patients with CKD.

When using any code under category 403 with fifth-digit 1 and any code under category 404 with fifth-digit 2 or 3, a secondary code from category 585 should be used to identify the stage of CKD.

Please review the full ICD-9-CM official code guidelines for fullloom expansion instructions. The address for the NOS classification website is: http://www.cdc.gov/nchs/icd9.htm
UNDIANOSED CKD CAN KILL.
How many of YOUR patients with diabetes, hypertension or cardiovascular disease have undiagnosed chronic kidney disease?

What Can You Do?

1. Determine Risk
   - Diabetes
   - Hypertension
   - Family history of diabetes, hypertension or CKD
   - U.S. ethnic minority status

2. Do 3 Simple Tests
   - Urinalysis to detect protein
   - Blood Pressure Measurement
   - Serum Creatinine to estimate GFR

3. Implement an Action Plan (see reverse)

4. Consider co-management with a nephrologist if the clinical action plan cannot be carried out. Refer to a nephrologist when GFR <30 mL/min/1.73 m².

The recommended method to estimate GFR is the MDRD Study equation:

Estimated GFR (mL/min/1.73m²)

\[ \text{GFR} = 186 \times (s_C)^{-1.154} \times \text{Age}^{-0.203} \times (0.742 \text{ if female}) \times (1.210 \text{ if African - American}) \]

\[ \text{or} \quad \exp[(5.228 - 1.154 \times s_C - 0.203 \times \text{Age}) - (0.742 \times \text{if female}) - (1.210 \text{ if African-American})] \]

\( s_C \) serum creatinine in mg/dL; age, in years.

- GFR is usually accepted as the best overall index of kidney function in health and disease. Normal GFR varies according to age, sex, and body size; in young adults it is approximately 120–130 mL/min/1.73 m² and declines with age. A decrease in GFR precedes the onset of kidney failure; therefore a persistently reduced GFR is a specific indication of CKD. Below 60 mL/min/1.73 m², the prevalence of complications of CKD increases, as does the risk of cardiovascular disease.

- The MDRD Study equation has not been validated in children (age <18 years), pregnant women, the elderly (age >70 years), racial or ethnic subgroups other than Caucasians and African Americans, in individuals with normal kidney function who are at increased risk for CKD, or in normal individuals. Despite these limitations, GFR estimates using equations are more accurate than serum creatinine alone.

- There are several significant limitations to estimating kidney function solely from serum creatinine. Serum creatinine concentration is affected by factors other than GFR, such as tubular secretion, generation, and extra-renal excretion of creatinine. Due to variation in these processes amongst individuals and over time within individuals, especially creatinine generation, there is a relatively wide range for serum creatinine in normal persons. As well GFR must decline to approximately half the normal level before the serum creatinine concentration rises above the upper limit of normal.

ONLINE AND DOWNLOADABLE TOOLS FROM THE NATIONAL KIDNEY FOUNDATION FOR IMPROVING PATIENT OUTCOMES

GFR Calculator
Clinical Action Plans for CKD with/without hypertension and/or diabetes
KDOQI Clinical Practice Guidelines
www.kidney.org/kl/professionals/tools.cfm

Frequently Asked Questions about GFR Estimates
www.kidney.org/professionals/kl/gfr.cfm
Free community screening: Kidney Early Evaluation Program (KEEP)

National Kidney Foundation
www.kidney.org
800.622-9010
Calculators for Health Care Professionals

Glomerular filtration rate (GFR) is the best overall index of kidney function. Normal GFR varies according to age, sex, and body size, and declines with age. NKF’s KDOQI clinical practice guidelines recommend the MDRD Study equation to estimate GFR. Other useful calculators related to kidney disease are also available below.

### 4 variable MDRD CKD EPI Equation (with SI Units)

using standardized serum creatinine, age, race, gender

by Stephen Z. Fadem, M.D., FACP, FASN
and Brian Rosenthal

<table>
<thead>
<tr>
<th>Variable</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum creatinine</td>
<td>mg/dL ◎ µmol/L</td>
</tr>
</tbody>
</table>

NOTE: CKD EPI GFR is only valid with creatinine methods are traceable to IDMS

<table>
<thead>
<tr>
<th>Age</th>
<th>Race</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 years</td>
<td>African American ◎ All other races*</td>
<td>Male ◎ Female</td>
</tr>
</tbody>
</table>

TRACEABLE TO IDMS (what is this?) | No ◎ Yes

Click here to create an individualized CKD clinical action plan for your patient
CALCULATORS AND MODELING AIDS

eGFR / 1.73 M² by MDRD and by CKD-EPI

Serum Cr: [ ] Unit: mg/dL [ ] Age: [ ]
Gender: [M] [F] Race: [Other] [ ]

- Please enter the Serum Creatinine value.
- Please enter the patient's age.

Get the iPhone eGFR CKD-EPI/MDRD calculator
Get the Android eGFR CKD-EPI/MDRD calculator

Links:
- Schelling Pathologic Proteinuria Calculator (Dipstick +/Specific Gravity)
- What is the BMI (Body Mass Index)? - From the NHLBI website
- Caloric Content of Foods
There is a Lot to Manage!

CKD

- Interventions that delay progression
- Prevention of uremic complications
- Modification of comorbidity
- Preparation for KRT

- ACE inhibitors
- Malnutrition
- Cardiac disease
- Education

- BP control
- Anemia
- Vascular disease
- Informed choice of KRT

- Blood sugar control
- Osteodystrophy
- Neuropathy
- Timely access

- Protein restriction?
- Acidosis
- Retinopathy
- Timely initiation of dialysis

- Lipid Control
Complications of CKD Associated with Level of GFR

A Curriculum for CKD Risk Reduction and Care

- Public Education
- Kidney Learning System (KLS)™

<table>
<thead>
<tr>
<th>GFR 130</th>
<th>90</th>
<th>60</th>
<th>30</th>
<th>15</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAGE 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STAGE 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STAGE 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STAGE 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STAGE 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Dyslipidemia
- Hypertension
- Anemia
- Nutrition
- Bone Disease
- Neurological Changes
- Functioning & Well-being
ANEMIA

- Decreased $O^2$
- LVH – left ventricular hypertrophy
- Heart remodells
- Heart Failure

**CHRONIC KIDNEY DISEASE AND ANEMIA**

One of the kidney's functions is to produce the hormone called erythropoietin, which stimulates bone marrow production of red blood cells. Since erythropoietin generation is markedly decreased in patients with CKD, leading to reduced red blood cell production. Anemia is typically present with a diagnosis of CKD.
Decreased *erythropoietin* leads to anemia and increased cardiac preload and decreased vascular resistance. Resulting high cardiac output causes left ventricular hypertrophy and dilatation.

Left ventricular chamber dilated and left ventricular wall thickened.
Consequences of Poor Phosphorus and Calcium Control

**Metastatic calcification**

Elevated phosphorus and calcium × phosphorus (Ca × P) product place dialysis patients at risk for metastatic calcification. Calcium deposits may form in the joints, organs, and elsewhere in the body. Patients may notice red eyes and itchy skin.

**Articular metastatic calcification**

**Visceral metastatic calcification**

**Calcification of the heart**

**Calciphylaxis**

Calciphylaxis causes severe skin lesions that may bleed or become infected. This condition may occur in patients with elevated phosphorus, calcium, and (often) parathyroid hormone (PTH). The risk may be greatest in patients who are obese.

**Calciphylaxis of the toes**
The plan of care must address, but not limited to, the ff:

Dose of dialysis. The interdisciplinary team must provide the necessary care and services to manage the patient’s volume status.
CMS CfC V504 – *Blood pressure and fluid needs*

IDT comprehensive assessment
1. pre/intra/post and interdialytic BP
2. IDWG
3. EDW or target weight
4. Intradialytic symptoms – root causes
Human body ~ 60% Water

- Sodium (major extracellular cation) – influences extracellular fluid volume
- IDWG – constant challenge in ESRD
- Difficult to achieve euvolemia
Three Compartment Model

Intra-cellular Space

Extra-cellular Space

Circulating Blood Volume

Intra-Vascular Space

Toxins

Fluid

23 Liters

17 Liters

5 Liters

Dialysate Flow

Toxins

Fluid

HemaMetrics
Adverse effects of fluid accumulation

- Hypertension
- Left ventricular hypertrophy
- Cardiovascular complications
- Respiratory symptoms
- Peripheral edema
- Ascites
- Hospitalizations
Why do we drink?

- Physical need
- Customs
- Socialization
- **Alleviate thirst**
- Disease
- Take prescribed medications
Salt and Sodium are not the same

- Salt – essential in small amounts (fluid balance, transmit nerve impulses, muscle contraction)
- ~ 40% sodium
The Importance of Population-Wide Sodium Reduction as a Means to Prevent Cardiovascular Disease and Stroke: A Call to Action From the American Heart Association


_Circulation_ published online Jan 13, 2011;
DOI: 10.1161/CIR.0b013e31820d0793

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The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org
Table. Key Points

- Elevated blood pressure (BP) is a leading, preventable cause of mortality and morbidity in the United States and throughout the world.

- The relation of BP and adverse health outcomes is direct, progressive, consistent, continuous, independent, and etiologically relevant throughout the range of usual BP starting at a level of approximately 115/75 mm Hg.

- A diverse body of evidence has implicated excess sodium intake in the pathogenesis of elevated BP.

- Independent of its effects on BP, excess sodium intake adversely affects the heart, kidneys, and blood vessels.

- Current intake of sodium greatly exceeds 1500 mg/d, the upper level of intake recommended by the American Heart Association and the 2010 Dietary Guidelines Scientific Advisory Committee.

- The potential public health benefits of sodium reduction are enormous and extend to virtually all Americans.
5% added while cooking
6% added while eating
12% from natural sources
77% from processed and prepared foods

http://www.mayoclinic.com/health/sodium/NU00284
### USDA National Nutrient Database for Standard Reference, Release 17

Sodium, Na (mg) Content of Selected Foods per Common Measure, sorted alphabetically

<table>
<thead>
<tr>
<th>NDB_No</th>
<th>Description</th>
<th>Weight (g)</th>
<th>Common Measure</th>
<th>Content per Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>14006</td>
<td>Alcoholic beverage, beer, light</td>
<td>354</td>
<td>12 fl oz</td>
<td>14</td>
</tr>
<tr>
<td>14003</td>
<td>Alcoholic beverage, beer, regular</td>
<td>355</td>
<td>12 fl oz</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Beef, top sirloin, separable lean only, trimmed to 1/8” fat, all grades,</td>
<td>85</td>
<td>3 oz</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>cooked, broiled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11090</td>
<td>Broccoli, raw</td>
<td>88</td>
<td>1 cup</td>
<td>29</td>
</tr>
<tr>
<td>11099</td>
<td>Brussels sprouts, cooked, boiled, drained, without salt</td>
<td>156</td>
<td>1 cup</td>
<td>33</td>
</tr>
<tr>
<td>11143</td>
<td>Celery, raw</td>
<td>40</td>
<td>1 stalk</td>
<td>32</td>
</tr>
<tr>
<td>11143</td>
<td>Celery, raw</td>
<td>120</td>
<td>1 cup</td>
<td>96</td>
</tr>
<tr>
<td>21098</td>
<td>Fast foods, cheeseburger, large, single patty, with condiments and</td>
<td>219</td>
<td>1 sandwich</td>
<td>1108</td>
</tr>
<tr>
<td></td>
<td>resemblable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yogurt, fruit, low fat, 10 grams protein per 8 ounce</td>
<td>227</td>
<td>8-oz container</td>
<td>132</td>
</tr>
<tr>
<td>01117</td>
<td>Yogurt, plain, low fat, 12 grams protein per 8 ounce</td>
<td>227</td>
<td>8-oz container</td>
<td>139</td>
</tr>
<tr>
<td>01118</td>
<td>Yogurt, plain, skim milk, 13 grams protein per 8 ounce</td>
<td>227</td>
<td>8-oz container</td>
<td>175</td>
</tr>
<tr>
<td>01116</td>
<td>Yogurt, plain, whole milk, 8 grams protein per 8 ounce</td>
<td>227</td>
<td>8-oz container</td>
<td>104</td>
</tr>
</tbody>
</table>
# Same Foods — BIG Difference in Sodium

The amount of sodium in processed foods varies a LOT by brand.

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving Size</th>
<th>Range of Sodium (mg) per Serving*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canned soup</td>
<td>1 cup</td>
<td>50-950</td>
</tr>
<tr>
<td>Canned vegetables</td>
<td>½ cup</td>
<td>10-550</td>
</tr>
<tr>
<td>Sliced bread</td>
<td>1 slice</td>
<td>100-240</td>
</tr>
<tr>
<td><strong>Frozen cheese pizza</strong></td>
<td>1 slice</td>
<td><strong>510-1090</strong></td>
</tr>
<tr>
<td>Frozen meals</td>
<td>6-10 ounces</td>
<td>330-1130</td>
</tr>
<tr>
<td>Tomato juice</td>
<td>8 ounces</td>
<td>140-680</td>
</tr>
<tr>
<td>Salad dressing</td>
<td>2 tablespoons</td>
<td>80-620</td>
</tr>
<tr>
<td>Salsa</td>
<td>2 tablespoons</td>
<td>90-250</td>
</tr>
<tr>
<td>Potato chips</td>
<td>1 ounce</td>
<td>10-380</td>
</tr>
<tr>
<td>Pretzels</td>
<td>1 ounce</td>
<td>50-610</td>
</tr>
</tbody>
</table>

*Based on a convenience sample

IDWG is influenced by sodium consumption

- **DIETARY SODIUM RESTRICTION**
- Read labels - **portion size**
- Processed foods
- Eating out
Hypertension

- Studies have shown that 80% of all HTN in dialysis patients → chronic hypervoleemia
- CV deaths and strokes linked to markers of volume overload
Core Curriculum

Fluid balance, dry weight, and blood pressure in dialysis

Bernard CHARRA
Centre de soins artificiels, Toulouse, France
**Table 1. Classification and Management of Blood Pressure for Adults Aged 18 Years or Older**

<table>
<thead>
<tr>
<th>BP Classification</th>
<th>Systolic BP, mm Hg*</th>
<th>Diastolic BP, mm Hg*</th>
<th>Lifestyle Modification</th>
<th>Initial Drug Therapy Without Compelling Indication</th>
<th>Initial Drug Therapy With Compelling Indications†</th>
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<td>Prehypertension</td>
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<td>Stage 1 hypertension</td>
<td>140-159 or 90-99</td>
<td>Yes</td>
<td>Thiazide-type diuretics for most; may consider ACE inhibitor, ARB, β-blocker, CCB, or combination</td>
<td>Drug(s) for the compelling indications</td>
<td>Other antihypertensive drugs (diuretics, ACE inhibitor, ARB, β-blocker, CCB) as needed</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
<td>≥160 or ≥100</td>
<td>Yes</td>
<td>2-Drug combination for most (usually thiazide-type diuretic and ACE inhibitor or ARB or β-blocker or CCB)§</td>
<td>Drug(s) for the compelling indications</td>
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Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin-receptor blocker; BP, blood pressure; CCB, calcium channel blocker.

* Treatment determined by highest BP category.
† See Table 6.
‡ Treat patients with chronic kidney disease or diabetes to BP goal of less than 130/80 mm Hg.
§ Initial combined therapy should be used cautiously in those at risk for orthostatic hypotension.
Examples

100 kg patient

- 3% - 3 Liters IDWG = 1.5 L/day
- 4% - 4 Liters IDWG = 2.0 L/day

50 Kg patient

- 3% - 1.5 Liters IDWG = 750 mL/day
- 4% - 2.0 Liters IDWG = 1.0 L/day
Hospital treatment for fluid overload in the Medicare hemodialysis population.

Arneson TJ, Liu J, Qiu Y, Gilbertson DT, Foley RN, Collins AJ.

Chronic Disease Research Group, Minneapolis Medical Research Foundation, Minneapolis, MN 55404, USA. tarneson@cdrg.org

CONCLUSIONS: Among U.S. hemodialysis patients, fluid overload treatment is common and expensive. Further study is necessary to identify prevention opportunities.
Top 5 Ways to Stop A-Salting Your Kidney

When it comes to dietary sodium, less is certainly best. Yet Americans today consume 50% more than the recommended daily quantity of only one teaspoon of salt per day. Diets high in sodium increase blood pressure levels. High blood pressure damages the kidneys over time, and is a leading cause of kidney failure. In recognition of National Kidney Month and World Kidney Day, the National Kidney Foundation offers the top 5 tips to reduce salt in your diet.

Pathophysiology and Management of Fluid and Electrolyte Disturbances in Patients on Chronic Dialysis with Severe Hyperglycemia

Antonios H. Tzamaloukas,† Todd S. Ing,† Kostas C. Siamopoulos,§ Dominic S. C. Raj,† Moses S. Elisaf,§ Mark Rohrscheib,† and Glen H. Murata*†

*New Mexico Veterans Affairs Health Care System, Albuquerque, New Mexico, †University of New Mexico School of Medicine, Albuquerque, New Mexico, ‡Loyola University Chicago, Chicago, Illinois, and §University of Ioannina, Ioannina, Greece

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2008 pp. 431–439
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TABLE 1. Mechanisms causing fluid and solute abnormalities in hyperglycemia

- Gain in extracellular solute
- Osmotic diuresis
- Water intake secondary to thirst
- Ketoacidosis
- Concomitant diseases
Diabetes

- Polyneuropathy, Autonomic dysfunction,
- Postural hypotension

- Vascular damage
- LVH
- Over hydration
### Dialysis Treatment

**Current HD Order:**

<table>
<thead>
<tr>
<th>Order Date</th>
<th>Start Date</th>
<th>Prescribed Time (minutes)</th>
<th>Dialyzer</th>
<th>Prescribed BFR</th>
<th>Dialysate</th>
<th>Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>02/14/2011</td>
<td>02/14/2011</td>
<td>210</td>
<td>Optiflux Flo10K</td>
<td>400</td>
<td>Bicarb Kt 1.0; Ca 2.5; Na 141; Bicarb 38; Glucose 100</td>
<td>62.00 kg</td>
</tr>
</tbody>
</table>

### Review of last 12 HD Treatments:

<table>
<thead>
<tr>
<th>Date</th>
<th>Pre-Weight</th>
<th>Post-Weight</th>
<th>Dry Weight</th>
<th>Pre BP Sitting</th>
<th>Pre BP Standing</th>
<th>Post BP Sitting</th>
<th>Post BP Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/07/11</td>
<td>66.70 kg</td>
<td>61.50 kg</td>
<td>62.00 kg</td>
<td>142 / 59</td>
<td>137 / 49</td>
<td>114 / 58</td>
<td>116 / 65</td>
</tr>
<tr>
<td>03/07/11</td>
<td>66.50 kg</td>
<td>62.70 kg</td>
<td>62.00 kg</td>
<td>130 / 65</td>
<td>119 / 53</td>
<td>173 / 74</td>
<td>135 / 65</td>
</tr>
<tr>
<td>03/01/11</td>
<td>66.90 kg</td>
<td>62.40 kg</td>
<td>62.00 kg</td>
<td>159 / 65</td>
<td>160 / 63</td>
<td>164 / 61</td>
<td>154 / 73</td>
</tr>
<tr>
<td>03/02/11</td>
<td>66.40 kg</td>
<td>61.80 kg</td>
<td>62.00 kg</td>
<td>171 / 61</td>
<td>161 / 77</td>
<td>146 / 59</td>
<td>161 / 66</td>
</tr>
<tr>
<td>02/28/11</td>
<td>67.00 kg</td>
<td>62.90 kg</td>
<td>62.00 kg</td>
<td>185 / 60</td>
<td>185 / 91</td>
<td>163 / 71</td>
<td>163 / 67</td>
</tr>
<tr>
<td>02/26/11</td>
<td>65.80 kg</td>
<td>62.90 kg</td>
<td>62.00 kg</td>
<td>177 / 72</td>
<td>162 / 64</td>
<td>151 / 67</td>
<td>154 / 72</td>
</tr>
<tr>
<td>02/25/11</td>
<td>66.80 kg</td>
<td>62.80 kg</td>
<td>62.00 kg</td>
<td>167 / 68</td>
<td>152 / 68</td>
<td>155 / 59</td>
<td>130 / 60</td>
</tr>
<tr>
<td>02/23/11</td>
<td>57.10 kg</td>
<td>62.50 kg</td>
<td>62.00 kg</td>
<td>149 / 76</td>
<td>157 / 74</td>
<td>155 / 66</td>
<td>162 / 65</td>
</tr>
<tr>
<td>02/21/11</td>
<td>67.50 kg</td>
<td>62.40 kg</td>
<td>62.00 kg</td>
<td>163 / 66</td>
<td>161 / 59</td>
<td>162 / 64</td>
<td>150 / 61</td>
</tr>
<tr>
<td>02/10/11</td>
<td>64.70 kg</td>
<td>61.50 kg</td>
<td>62.00 kg</td>
<td>153 / 69</td>
<td>154 / 72</td>
<td>139 / 61</td>
<td>127 / 61</td>
</tr>
<tr>
<td>02/10/11</td>
<td>67.00 kg</td>
<td>64.20 kg</td>
<td>62.00 kg</td>
<td>173 / 51</td>
<td>163 / 75</td>
<td>173 / 65</td>
<td>172 / 70</td>
</tr>
<tr>
<td>02/14/11</td>
<td>65.90 kg</td>
<td>61.60 kg</td>
<td>63.50 kg</td>
<td>167 / 75</td>
<td>150 / 75</td>
<td>174 / 56</td>
<td>167 / 66</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Result</th>
<th>Units</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/17/11</td>
<td>13:25</td>
<td>9.0 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>10/13/10</td>
<td>13:10</td>
<td>6.3 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>8/7/10</td>
<td>06:00</td>
<td>7.5 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>7/14/10</td>
<td>13:15</td>
<td>7.9 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>4/14/10</td>
<td>09:50</td>
<td>7.9 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>1/13/10</td>
<td>17:35</td>
<td>8.1 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>10/14/09</td>
<td>10:00</td>
<td>8.0 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>7/15/09</td>
<td>10:00</td>
<td>9.1 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>4/8/09</td>
<td>10:15</td>
<td>8.3 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>2/11/09</td>
<td>10:05</td>
<td>9.1 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>1/14/09</td>
<td>10:00</td>
<td>7.7 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>10/8/08</td>
<td>13:20</td>
<td>6.4 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
<tr>
<td>7/3/08</td>
<td>13:30</td>
<td>6.7 H</td>
<td>%</td>
<td>4.6-5.2</td>
</tr>
</tbody>
</table>
## HbA1c Results and Equivalent Average Blood Glucose Level

<table>
<thead>
<tr>
<th>HbA1c Test Result</th>
<th>Average Blood Glucose in mg/dL</th>
<th>Average Blood Glucose in mmol/L</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4%</td>
<td>65</td>
<td>3.61</td>
<td>Blood glucose average too low for persons with diabetes&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>5%</td>
<td>100</td>
<td>5.5</td>
<td>Blood glucose may be too tightly controlled&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>6%</td>
<td>135</td>
<td>6.6</td>
<td>Blood glucose very well managed</td>
</tr>
<tr>
<td>7%</td>
<td>170</td>
<td>8.3</td>
<td>Blood glucose very well managed</td>
</tr>
<tr>
<td>8%</td>
<td>205</td>
<td>10.0</td>
<td>Marginally managed, take action to lower</td>
</tr>
<tr>
<td>9%</td>
<td>240</td>
<td>11.6</td>
<td>Poorly managed, corrective action required</td>
</tr>
<tr>
<td>10%</td>
<td>275</td>
<td>13.3</td>
<td>Poorly managed, corrective action required</td>
</tr>
<tr>
<td>11%</td>
<td>310</td>
<td>17.2</td>
<td>Poorly managed, corrective action required</td>
</tr>
<tr>
<td>12%</td>
<td>345</td>
<td>19.16</td>
<td>Very poorly manage, corrective action required</td>
</tr>
<tr>
<td>13%</td>
<td>380</td>
<td>21.2</td>
<td>Very poorly manage, corrective action required</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> Refer to the source for detailed explanations.
Assessment of Dry Weight

- EDW (Estimated Dry Weight), Target weight
- "Dry" weight
- Normotensive, minimum to no BP meds, asymptomatic, no edema
IDWG

- IDWG ≥4.8% = ↑mortality

*Blood pressure and long-term mortality in United States hemodialysis patients: USRDS Waves 3 and 4 Study.*


- Standard ~ 3-5% of EDW
Kidney International advance online publication 6 October 2010; doi: 10.1038/ki.2010.383

- Rapid fluid removal during dialysis is associated with cardiovascular morbidity and mortality
K/DOQI Guideline for Hemodialysis Adequacy

VI. Maximizing patient adherence to hemodialysis prescription

Guideline 15 Optimizing Patient Comfort and adherence – prevent interdialytic symptoms

- Early termination - 70% cramps, 48% feeling sick, 15% Hypotension
- Early termination – affects adequacy
CLINICAL IMPORTANCE OF RESIDUAL RENAL FUNCTION

- Loss of RRF – patient’s volume control and survival outcomes
- Even with low - GFR = can still remove significant uremic toxins
- Urine output facilitates fluid and electrolyte balance
Common Complications

- Hypotension
- Cramps
- Nausea/vomiting
- Seizure (related to hypotension)
Hypotension

- Congestive Heart Failure: Peripheral Edema
- Loop Diuretics
- bumetanide
- furosemide
- ethacrynic acid

- X-ray of lungs
Hypotension

- BP Meds
- Heavy Meals – splanchnic vasodilation
- Excessive UF
- Cardiac disease
- BP Cuff size/placement
- Advanced age
- DM
- Low Albumin
BP medications

- Not all BP meds are the same
- Drugs that also cause BP to drop
  1. Anti arrhythmics
  2. Beta blockers
- BP meds before HD usually recommended
- Look for patches (Clonidine, Nitro patch)
Blood Volume Monitoring

- Excellent tools
- BVM module in Fresenius K machines
- CritLine®
Three Compartment Model

Intracellular Space: 23 Liters
Extracellular Space: 17 Liters
Circulating Blood Volume: 5 Liters

Toxins
Fluid

Dialysate Flow

Test tube circulation
Total Blood Volume (BV)
Plasma Volume
Red Cell Volume (RCV)
Direct Feedback to the 2008 Machine

- Patient individual alert level
- Audible Warning
- Feedback control stops UF
Blood Volume Monitoring

- Hematocrit
- O2 Saturation

Hct = \( \frac{RCV}{BV} \times 100 \)
Fresenius Medical Care acquires Hema Metrics’ Crit-Line system
3/8/2011

Dialysis products and services provider Fresenius Medical Care AG & Co. announced the acquisition of all assets of Hema Metrics LLC related to its Crit-Line system. Based on its strong dialysis product business and sales organization, Fresenius Medical Care intends to establish this technology as the standard of care for fluid and anemia management in its North American market.

The Crit-Line system, Fresenius announced, is an excellent fit with Fresenius Medical Care North America’s 2008K, 2008K2, and 2008T hemodialysis machines.

The Crit-Line system enables noninvasive optical measurement of absolute blood parameters such as percent blood volume change, absolute hematocrit level and continuous oxygen saturation. The Crit-Line system is an effective tool for the clinician to improve fluid management with less clinical complications, such as hypotension. Improved fluid management may lead to fewer hospitalizations for renal patients. The Crit-Line system and its associated products are FDA 510(k) cleared, and carry the CE mark.
No blood Volume Monitor?

- UF Profile
- Na Profile
- Give O2 if known hemoglobin is low especially if UF rate is high
- Longer treatment, sequential UF
- Extra treatment – isolated UF
- At next treatment, increase UF goal in small increments
UF Profile

- Variable settings
- Need to select appropriate for patient
- Increases dialysis tolerance
- Know your patient
Sodium Profile

- Has benefits if utilized properly
- But may also cause patient to be in +Na balance = increase thirst = hypertension
- Need to be sodium neutral at the end
- Know your patient
Assessment/ Observation

- Vital signs (Blood Pressure, HR)
- Edema – may be caused my medications also
- Lung sounds
- Co-morbidities - Heart function, Ejection fraction, DM
- Lab values – Hgb, Albumin, blood sugar, Na
- Appetite changes, N/V, diarrhea
- Changes in urine output volume ( +/- )
- Meticulous weighing process – same scale, calibrated
- Dialysis “uniform”? – same clothes every dialysis
- Age
Things to consider

- Patients on HD have a very demanding medical regimen
- Knowledge deficits
- Psycho-social issues
- Economics
- Engage patient in self management
- Constant education
Clinical Pearls

- Blood Volume monitoring
- UF Profiling
- Sodium program
- Lower temperature
- More frequent HD
- Isolated UF, Sequential dialysis
- Frequent assessment of EDW
- Administer Oxygen for lower hemoglobin and PRN
Clinical Pearls

- Hypotension/cramps/other morbid events does not mean EDW was achieved.
- Lag time of a few weeks to months between modification in volume and BP response.
- Engage patient in self management.
In conclusion

- Fluid overload increases mortality in the ESDR population
- High sodium diet and poor glycemic control lead to fluid overload in the hemodialysis population
- Blood volume monitoring facilitates ultrafiltration during HD
- Engage patients in self management
Thank You for the Opportunity and your attention