



Brigham and Women's Hospital

Founding Member, Mass General Brigham

DIALYSIS AND TRANSPLANTATION

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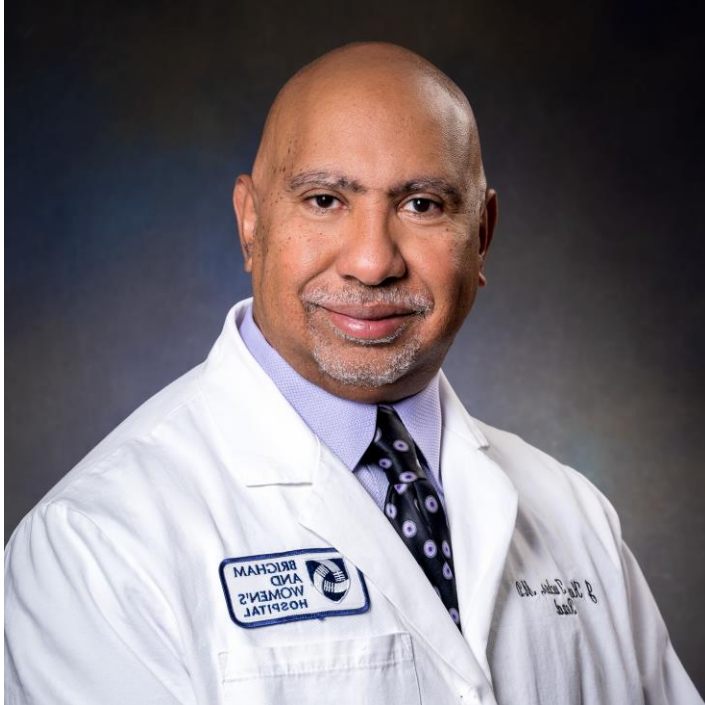
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Clinical focus: Hemodialysis and Peritoneal Dialysis

Disclosures

- None

Learning Objectives

- Understand the demographics of end-stage renal disease
- Review the principles of hemodialysis, peritoneal dialysis, and transplantation
- Discuss strategies to alleviate inequities in end-stage renal disease treatment

Case 1

An 81-year-old woman with advanced chronic kidney disease is admitted to hospital from a skilled nursing facility for worsening kidney function. Her creatinine has risen over the last several months to 5.0 mg/dL with an eGFR of 8 mL/min. Her potassium is 4.9 mEq/L and CO₂ is 19 mmol/L. Hemoglobin is 9.1 g/dL. Her co-morbidities include type 2 diabetes and hypertension. She has been bedbound since a CVA seven months prior. Her appetite has been stable. She has no specific symptoms of uremia.

Case 1 Audience Response Question

Which of the following is most appropriate in management of this patient?

- A) Placement of a peritoneal dialysis catheter
- B) Referral for kidney transplantation
- C) Placement of a non-tunneled hemodialysis catheter
- D) Medical management of her chronic kidney disease and palliative care referral

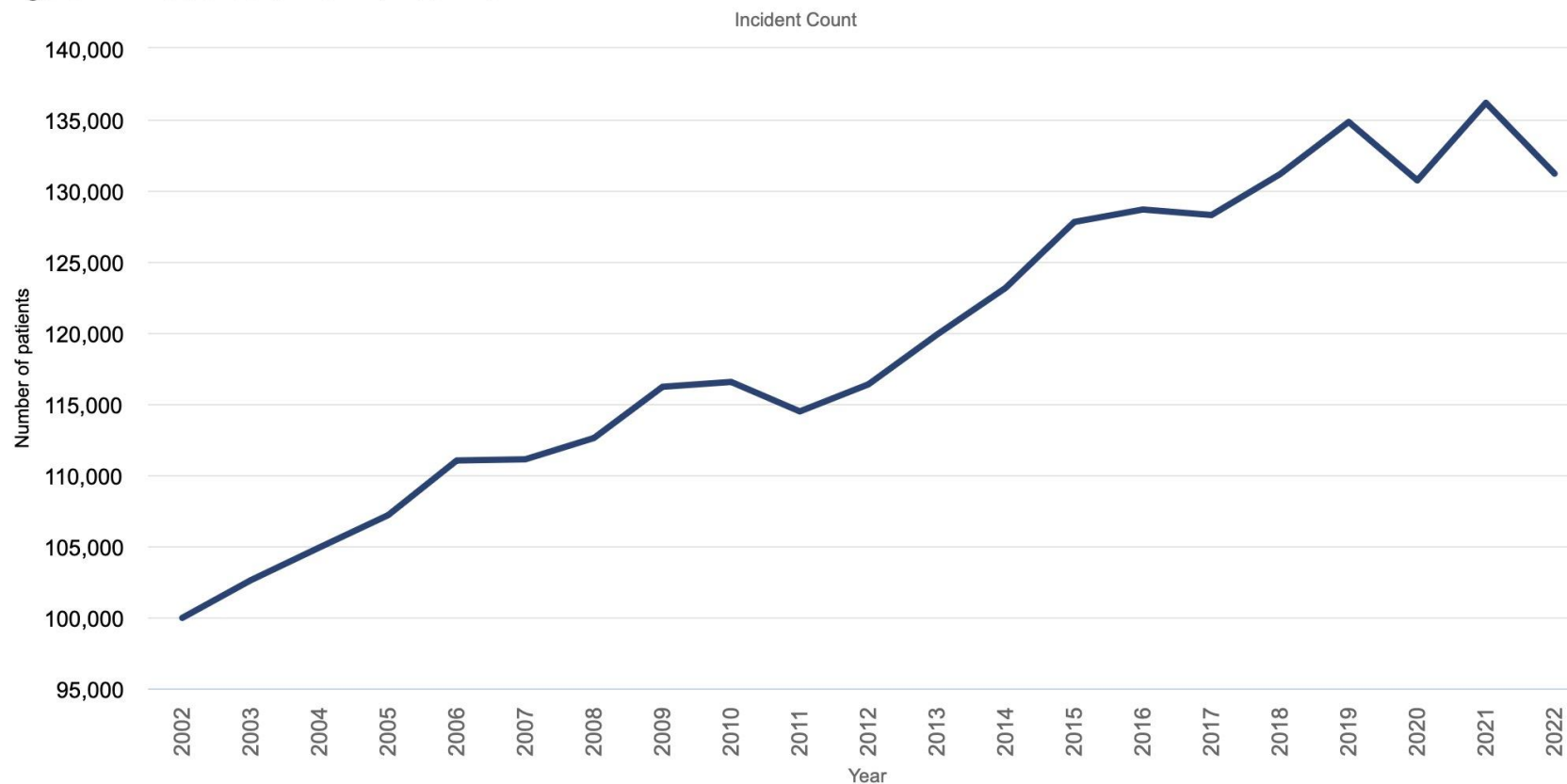
Renal replacement therapy

General nomenclature used to designate the forms of therapy to replace kidneys that no longer are adequate to maintain life

- Hemodialysis
- Peritoneal dialysis
- Transplantation

Adjusted incidence of ESRD, 2002-2022

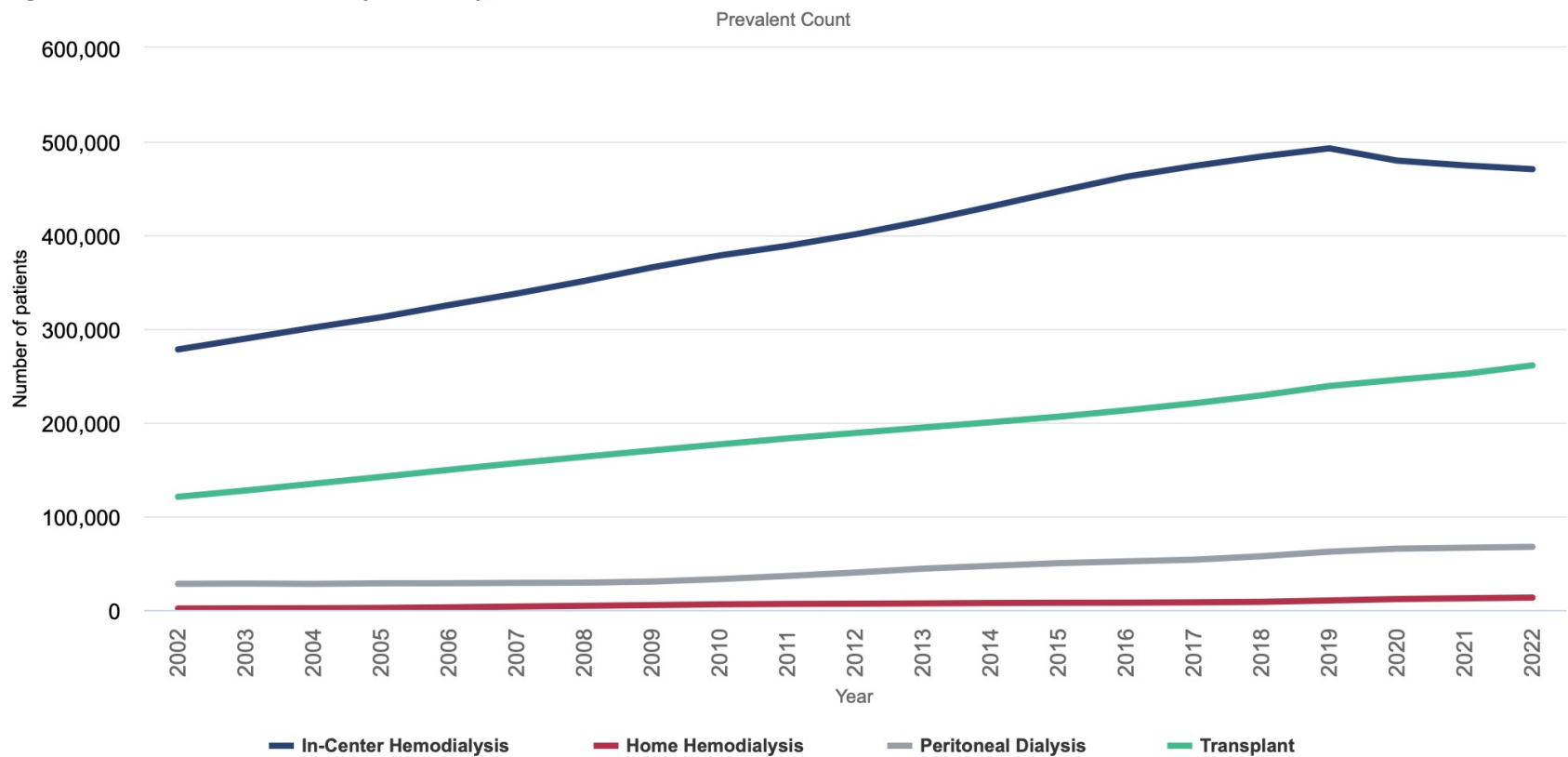
Figure 1.1 Incidence of ESRD, 2002-2022



Data Source: 2024 United States Renal Data System Annual Data Report

Prevalent ESRD patients by modality, 2002-2022

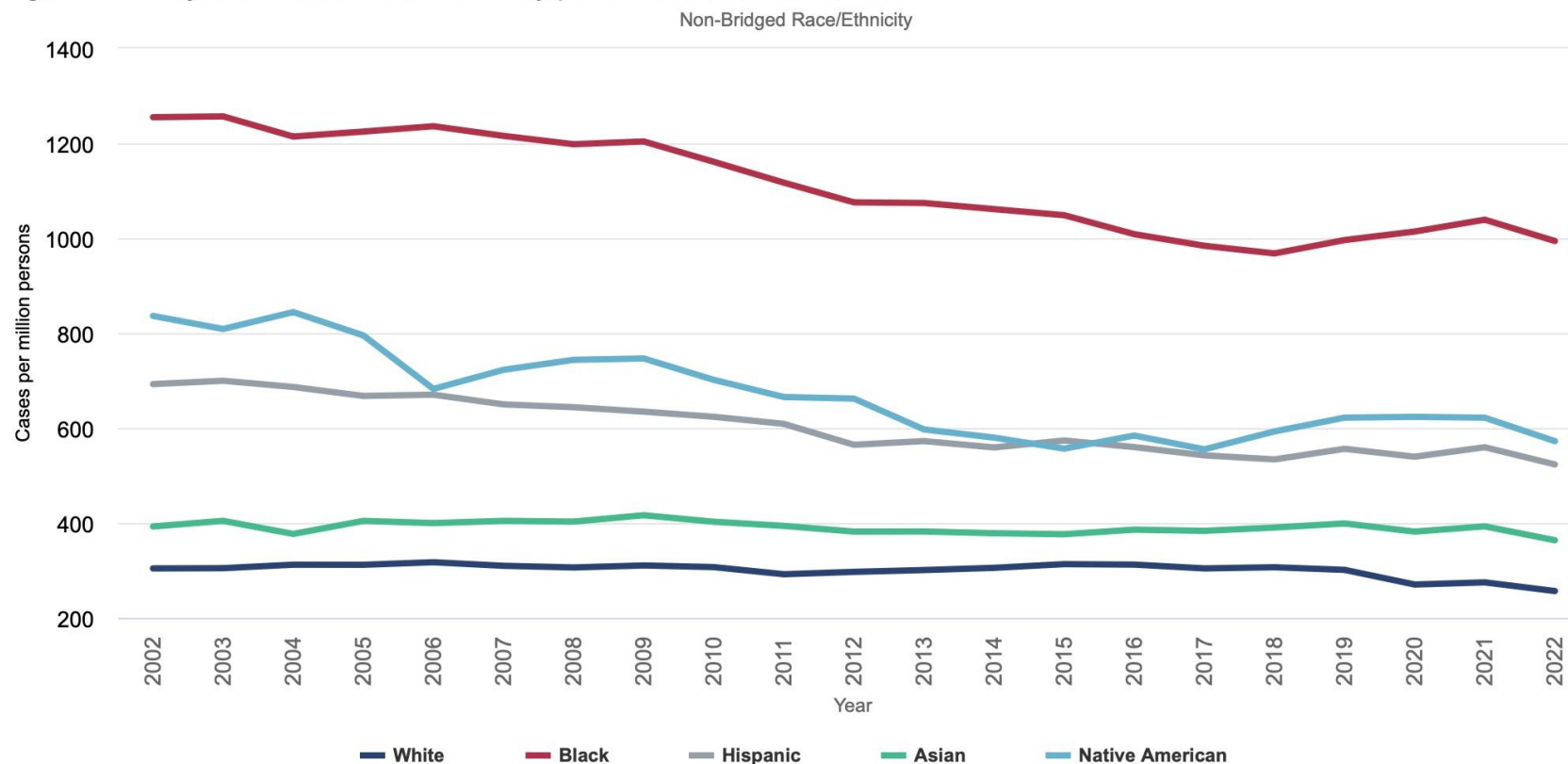
Figure 1.8 Prevalent ESRD by modality, 2002-2022



Data Source: 2024 United States Renal Data System Annual Data Report

Adjusted ESRD incidence by race

Figure 1.4a Adjusted incidence of ESRD by patient characteristics, 2002-2022

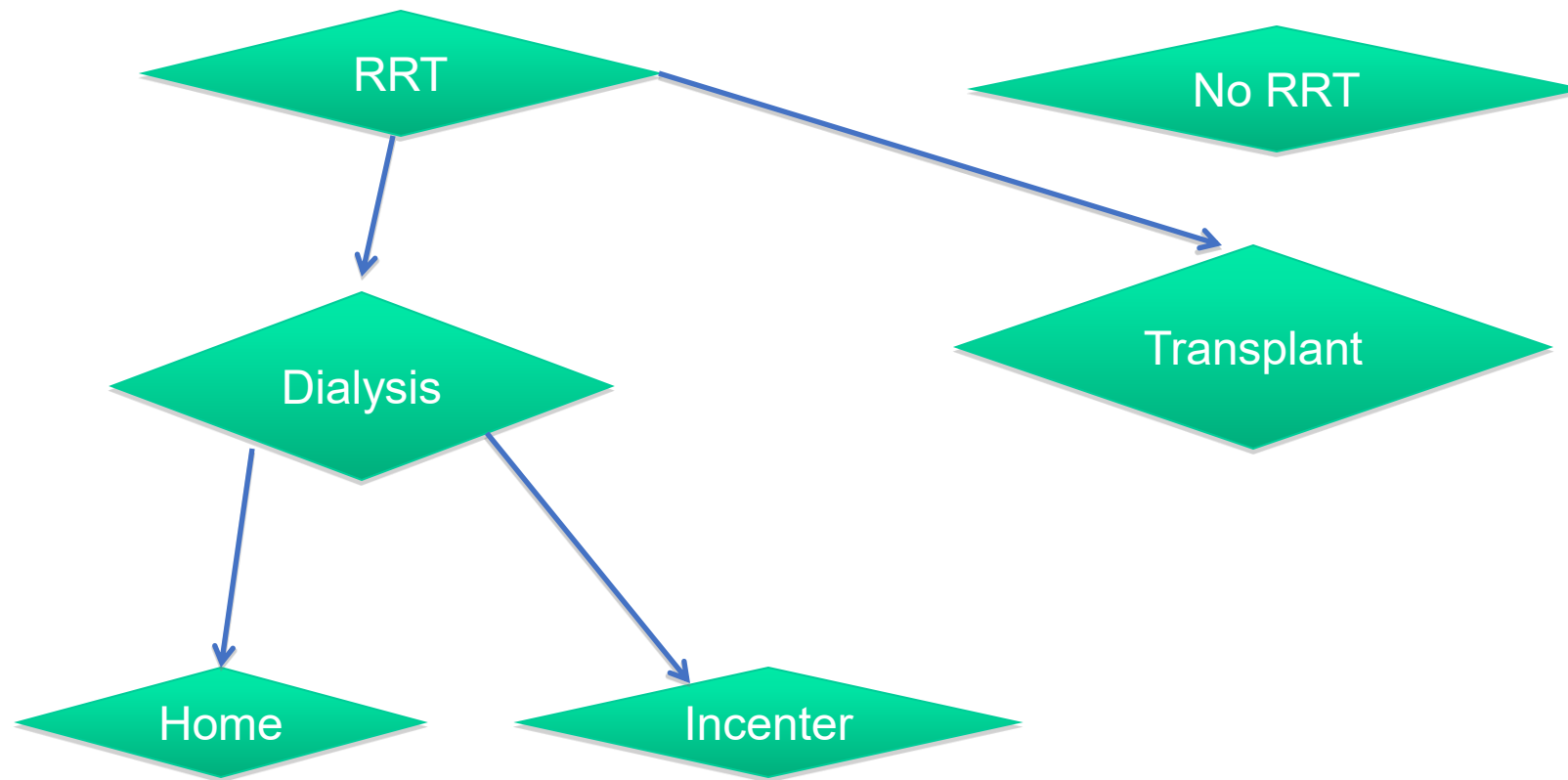


Data Source: 2024 United States Renal Data System Annual Data Report

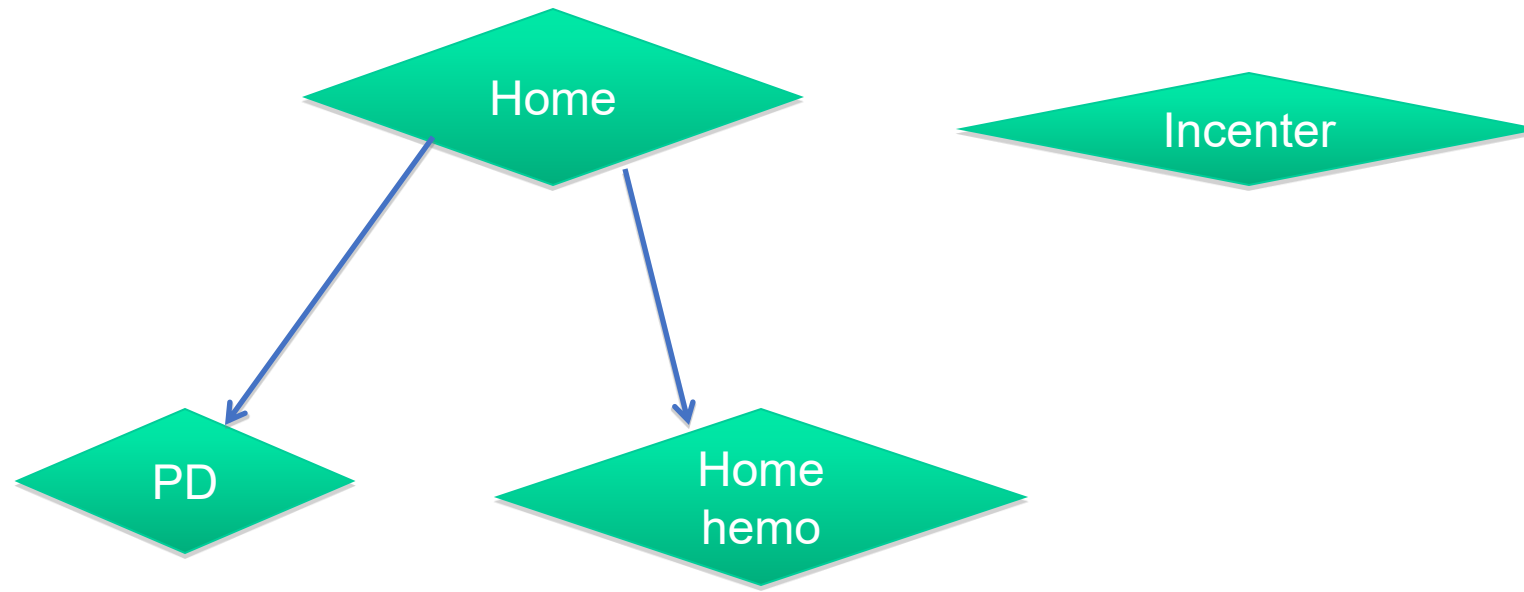
Indications for dialysis

- Acid-base disturbances (severe metabolic acidosis)
- Electrolyte abnormalities (hyperkalemia)
- Ingestions (ethylene glycol, methanol, salicylates)
- Fluid Overload (CKD + CHF)
- Uremia
 - Nausea/Vomiting
 - Anorexia
 - Dysgeusia
 - Pruritus
 - Pericarditis

Renal replacement decision tree



Renal replacement decision tree

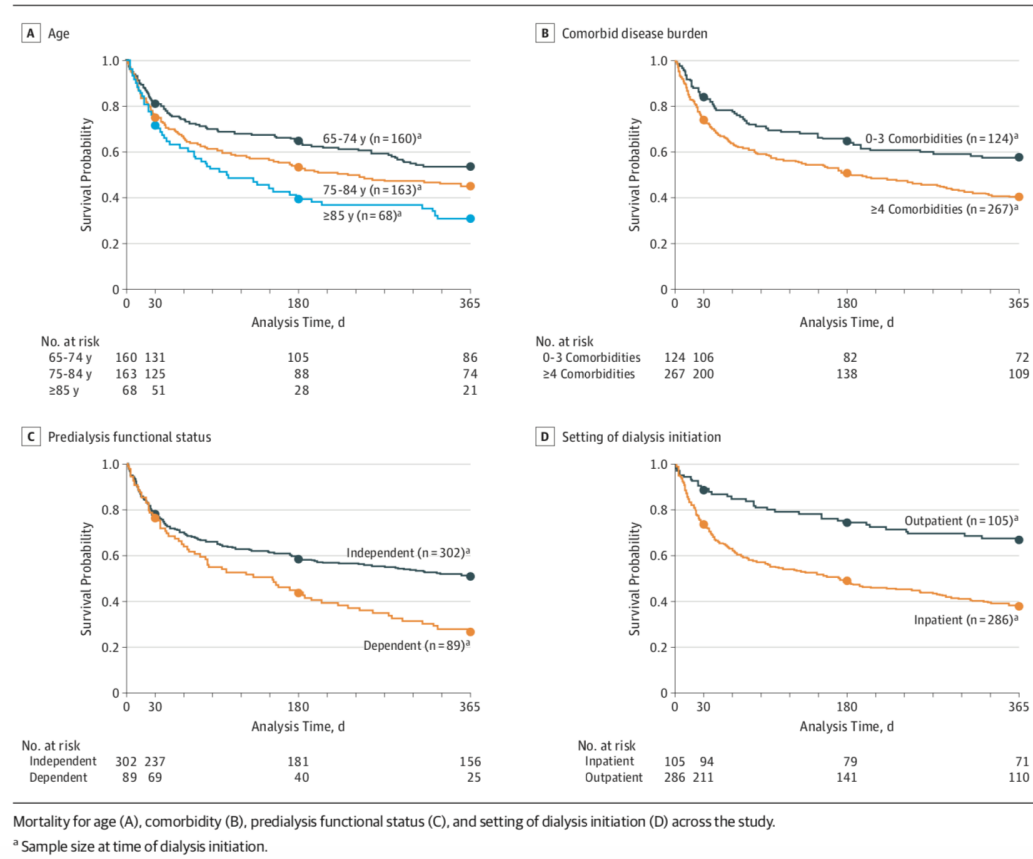


If dialysis is chosen

- Conservative (non-dialysis) therapy may be appropriate in some patients
 - No increase in survival and no improvement in quality of life in frail elderly who are started on dialysis
- Create a vascular access or place a peritoneal dialysis catheter
- Manage metabolic complications
- Manage nutrition



High mortality among the elderly starting dialysis



Wachterman M *et al* JAMA Internal Med. 2019; 179: 987-990

Long-term Outcomes Among Patients with Advanced Kidney Disease Who Forgo Maintenance Dialysis

- Systematic review of 41 cohort studies comprising 5102 adults with advanced kidney disease who did not pursue dialysis
- Forty-one cohort studies comprising 5102 patients (range, 11-812 patients) were included in this systematic review .
- Median survival of cohorts ranged from 1 to 41 months as measured from a baseline mean estimated glomerular filtration rate ranging from 7 to 19 mL/min/1.73 m²
- Patients generally experienced 1 to 2 hospital admissions, 6 to 16 in-hospital days, 7 to 8 clinic visits, and 2 emergency department visits per person-year.

Long-term Outcomes Among Patients with Advanced Kidney Disease Who Forgo Maintenance Dialysis

- During an observation period of 8 to 24 months, mental well-being improved, and physical well-being and overall quality of life were largely stable until late in the illness course.
- Among patients who died during follow-up, 20% to 76% had enrolled in hospice, 27% to 68% died in a hospital setting and 12% to 71% died at home; 57% to 76% were hospitalized, and 4% to 47% received an invasive procedure during the final month of life.
- Many patients who do not pursue dialysis survived several years and experienced sustained quality of life until late in the illness course. Nonetheless, use of acute care services was common and intensity of end-of-life care highly variable across cohorts.

Case 1

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Case 1 Audience Response Question

Which of the following is most appropriate in management of this patient?

- A) Placement of a peritoneal dialysis catheter
- B) Referral for kidney transplantation
- C) Placement of a non-tunneled hemodialysis catheter
- D) Medical management of her chronic kidney disease and palliative care referral***

Case 2

A 26 -year-old man presents with anorexia and fatigue and is found to have a creatinine of 14 mg/dL, eGFR 4 mL/min, hemoglobin 7.8 g/dL, CO₂ 15 mmol/L, K⁺ 7.5 mEq/L. Both kidneys are atrophic by ultrasound. He is educated about dialysis modalities and chooses incenter hemodialysis. He begins dialysis in the hospital via a non-tunneled catheter.

Audience Response Question

Which of the following is the best **long-term** dialysis access for this patient?

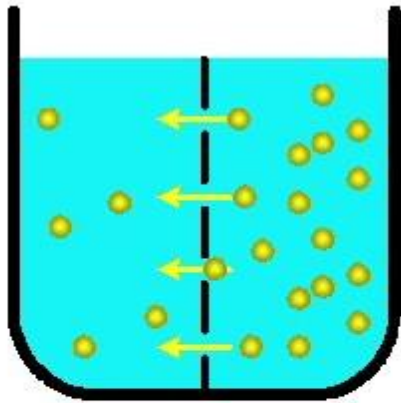
- A) Tunneled dialysis catheter
- B) AV graft
- C) AV fistula

Hemodialysis

Essential Components of Hemodialysis Procedure

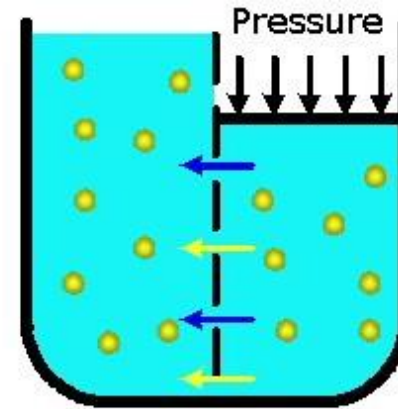
- Dialyzer
- Dialysate
- Access to circulation

Hemodialysis is a two-step process:
Diffusion/convection and ultrafiltration



Diffusion

(Solvent moves by
concentration gradient)

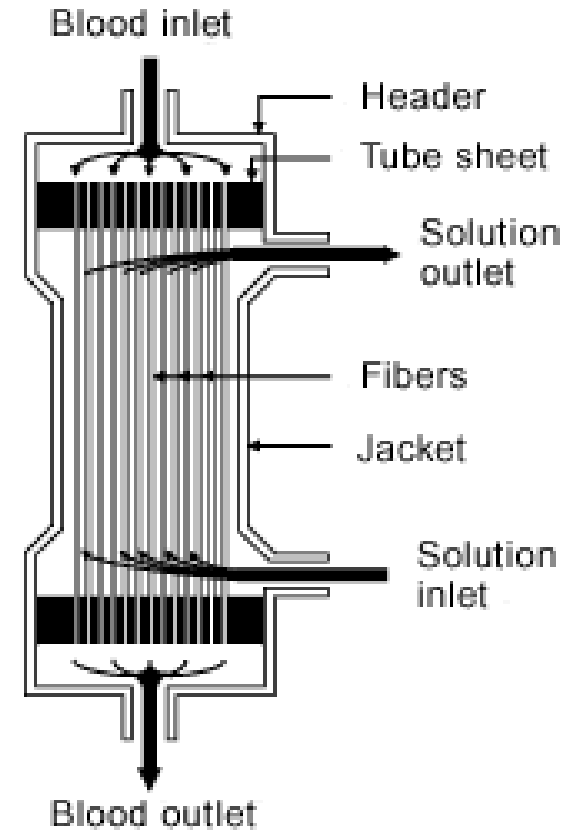


Ultrafiltration

(Solution moves by
pressure gradient)

Dialyzers

- Most commonly used dialyzers in the US are hollow-fiber dialyzers.
- Dialyzer shell is a tube with four ports.
- Two ports communicate with the blood compartment, and two ports communicate with the dialysate compartment.
- Blood flows through the fibers, and dialysate around the outside.



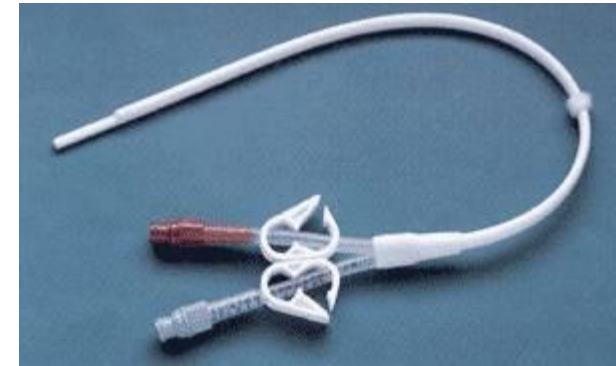
Dialysate Composition (mEq/L)

Sodium	135-145
Potassium	0-4.0
Calcium	2.5-3.5
Magnesium	0.5-0.75
Chloride	98-124
Acetate	2-4
Bicarbonate	30-40
Dextrose	11

Hemodialysis vascular access types

- AV fistula
 - Preferred vascular access type
 - Fewer interventions needed to maintain patency
 - Fewer infectious complications
- AV graft
 - More interventions required to maintain patency
- Catheter
 - Tunneled
 - Non-tunneled
 - Least desirable because of infection risk

Create vascular access early enough to avoid these



Outpatient hemodialysis

Once the patient is started on HD, he/she is referred to an outpatient unit, usually closet to his/her home.



Vascular access infection

- Infection is the second leading cause of death in ESRD patients.
- Catheters are the vascular access type most associated with infections.
- Catheter-related bacteremia may be due to Gram positive or Gram negative organisms.
- Nasal carriage of Staph aureus is a risk factor.

Catheter-associated bacteremia treatment

- Removal of the catheter and treatment with systemic antibiotics is the gold standard
- Other approaches
 - Catheter exchange with guidewire plus systemic antibiotics
 - Systemic antibiotics plus an antibiotic lock

Case 2

A 26 -year-old man presents with anorexia and fatigue and is found to have a creatinine of 14 mg/dL, eGFR 4 mL/min, hemoglobin 7.8 g/dL, CO₂ 15 mmol/L, K⁺ 7.5 mEq/L. Both kidneys are atrophic by ultrasound. He is educated about dialysis modalities and chooses incenter hemodialysis. He begins dialysis in the hospital via a non-tunneled catheter.

Case 2 Audience Response Question

Which of the following is the best **long-term** dialysis access for this patient?

- A) Tunneled dialysis catheter
- B) AV graft
- C) *AV fistula***

Case 3

A 65-year-old man with CKD stage 4 is admitted to the hospital with acute on chronic congestive heart failure. His ejection fraction is 20%. After an in-hospital V-fib arrest, he has a pacemaker-defibrillator implanted. He is a former professional football player who has undergone bilateral TKRs. Despite high-dose diuretics, he remains fluid overloaded and becomes less responsive to diuretics over the course of his hospitalization. Dialysis is suggested as a means of controlling his volume.

Case 3 Audience Response Question

Which dialysis modality may best be suited for this patient?

- A) Hemodialysis
- B) Peritoneal dialysis

Peritoneal dialysis

Physiology of PD

- The peritoneal membrane can serve as a diffusive surface for solutes to move from areas of high concentration to low concentration
- An osmotic gradient for fluid removal (ultrafiltration) is provided by glucose.

Composition of dialysate

Volume	2, 2.5, 3L most commonly for CAPD 6L for APD
Sodium	132 mEq/L
Potassium	0
Glucose	1.5, 2.5, 4.25 g/dL
Calcium	2.5, 3.5 mEq/L
Magnesium	0.5-1.5 mEq/L
Lactate	35-40 mEq/L



Types of PD

- CAPD = Continuous ambulatory peritoneal dialysis
 - Manual exchanges
- CCPD = Continuous cycling peritoneal dialysis
 - Use of an automated cyclor with a long daytime dwell

Utilization of PD in the United States

- PD is underutilized in the United States
 - About 8% of all dialysis patients
- When pre-dialysis modality education is provided, more patients will choose PD.
- PD patients report greater quality of life and greater satisfaction with therapy

Barriers to utilization of PD

- Patient factors
 - Lack of knowledge about PD
 - “I’m afraid.”
 - Poor social supports
 - Technical problems, e.g., limited manual dexterity
 - Aging patient population
- Physician factors
 - Lack of knowledge
 - Inadequate exposure during training

Peritonitis as a complication of PD: the leading cause of patient transfer to HD

- Signs and symptoms

- Fever
- Abdominal pain
- Abdominal tenderness/rebound
- Cloudy effluent
- Nausea/vomiting

- Diagnosis

- Effluent cell count
- WBC > 100/uL with 50% PMNs
- Effluent Gram stain
- Effluent culture

Treatment of peritonitis

- Bacterial peritonitis
 - Intraperitoneal antibiotics (vancomycin + ceftazidime, for example)
 - Catheter removal if infection does not clear
- Fungal peritonitis
 - Prompt catheter removal
 - Systemic anti-fungals

Prevention of peritonitis

- Nasal carriage of Staph aureus is a risk factor.
- Daily application of a topical antibiotic reduces episodes of peritonitis and exit-site infection
 - Mupirocin
 - Gentamicin

PD or HD: Most patients can do either modality

PD may be the preferred modality in certain situations:

- Patients with HFrEF
- Patients with hardware (pacemakers, defibrillators, knee or hip prostheses, etc)
- Immunocompromised patients
- Patients with clotting tendencies, including lupus
- Patients for whom schedule flexibility is important
- Patients for whom control is important

Case 3

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Case 3 Audience Response Question

Which dialysis modality may best be suited for this patient?

A) Hemodialysis

B) Peritoneal dialysis

Case 4

A 67-year-old man underwent kidney transplantation at age 27 for chronic kidney disease of undetermined etiology. He has maintained excellent allograft function for 40 years (serum creatinine 1.0 mg/dL) with an immunosuppressive regimen of azathioprine and low-dose prednisone. He develops gout and after the acute attack has resolved, he is prescribed allopurinol for treatment of hyperuricemia. Two months later he presents with dyspnea and fatigue and is found to have a hemoglobin of 6.2 g/dL, down from his baseline hemoglobin of 13 g/dL.

Case 4 Audience Response Question

What is the most likely explanation for this patient's anemia?

- A) Upper GI bleed
- B) Post-transplant lymphoproliferative disorder
- C) Multiple myeloma
- D) Allopurinol

Kidney transplantation

- The optimal form of renal replacement
- Limited by organ availability
- Organ sources:
 - Living related donors
 - Living unrelated donors
 - Deceased donors
 - Extended criteria donors

Medical evaluation of the transplant recipient

- Kidney recipients require multidisciplinary team evaluation:
 - Surgeon
 - Nephrologist
 - Social worker
 - Pharmacist
 - Psychiatrist

Medical evaluation

- Cardiovascular disease
- Malignancies
- Infections
 - HIV
 - Hepatitis B
 - Hepatitis C
 - Syphilis
 - CMV
 - EBV

Immunosuppression for kidney transplantation

Glucocorticoids		Block cytokine synthesis Weight gain, hyperglycemia, cataracts osteoporosis
Azathioprine		Inhibits purine biosynthesis Major interaction with allopurinol
Mycophenolate		Selective effect on lymphocyte replication GI side effects
Calcineurin Inhibitors	Cyclosporine	Gingival hyperplasia Hypertension Hirsutism
	Tacrolimus	Diabetes Hypertension Neurotoxicity

Immunosuppression for kidney transplantation

Sirolimus	mTOR inhibitor Bone marrow suppression Hyperlipidemia
Monoclonal antibodies (basiliximab and daclizumab)	Block activated T-cells expressing IL2 receptor
Monoclonal antibody (Belatacept)	Blocks costimulation of lymphocytes by inhibiting the interaction between CD80/86 and CD28
Polyclonal antibodies (ATGAM and thymoglobulin)	Non-specifically block T-cells

Drugs/susbtances that alter cyclosporine metabolism

Increase level of cyclosporine	Decrease level of cyclosporine
Diltiazem	Barbiturates
Verapamil	Phenytoin
Nicardipine	Carbamazepine
Amlodipine	Isoniazid
Ketoconazole	Rifampin
Fluconazole	
Erythromycin	
Clarithromycin	
Grapefruit juice	

Infectious complications post-transplant

- First month
 - Surgical wound infections
 - Urinary tract infections
 - Catheter-related bacteremia

Infectious complications post-transplant

- 1-6 months
 - CMV
 - EBV
 - *Pneumocystis jiroveci*
 - *Nocardia*
 - *Listeria monocytogenes*
 - Prophylaxis with TMP-SMX, dapsone, valganciclovir

Infectious complications post-transplant

- After 6 months
 - Infectious risk decreases as immunosuppression is reduced.
 - CMV disease may occur late
 - Fever
 - Leukopenia
 - Malaise
 - Allograft dysfunction

Non-infectious complications of kidney transplantation

- Cardiovascular disease
- NODAT
- Malignancies
 - Skin cancer
 - Cervical cancer
- Post-transplant lymphoproliferative disorder

Equity Issues in Dialysis and Transplantation

- African-American patients despite having a higher burden of ESRD
 - 24% less likely to receive a kidney transplant
 - Less likely to be referred for pre-emptive transplantation
- Barriers to African-Americans Utilizing Home Dialysis and Receiving Transplants
 - Limited knowledge of home modalities and deceased donor options
 - Little thought to renal replacement options
 - CKD patients relied on doctors for treatment decisions
 - Knowledge about living donor kidney transplantation did not result in patients receiving one

King A et al. *Journal of Renal Care* 2020 <https://doi.org/10.1111/jorc.12312>

Patzer RE et al. *J Am Soc Nephrol* 2017; 28: 935-42

Gander JC et al. *Clin Transplant* 2018 Sep;32(9):e13380. doi: 10.1111/ctr.13380. Epub

2018 Aug 26

Strategies to Eliminate Inequities in Home Dialysis and Transplantation

- Unconscious bias training
- Patient education programs
- Partnering with trusted community members
 - Community health workers
 - Patient navigators
 - Barbershop/Beauty shop programs

Increasing access to
transplantation:
Xenotransplantation

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02:48

In a first, doctors at Mass General transplanted a pig kidney into a living patient

Updated March 22, 2024

By [Priyanka Dayal McCluskey](#)



Case 4

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- D) Allopurinol***

Summary

- Renal replacement options for the patient with advanced CKD include transplantation, hemodialysis, and peritoneal dialysis.
- Conservative (non-dialytic) treatment may be appropriate for some patients with advanced CKD.
- Preparation for renal replacement should include the timely placement of a vascular access or PD catheter.

Summary

- The AV fistula is the preferred vascular access for hemodialysis.
- Nasal carriage of Staph aureus is a risk factor for infectious complications in both hemodialysis and peritoneal dialysis.
- Peritonitis is the leading cause of transfer from PD to HD.

Summary

- Kidney transplantation is the optimal form of renal replacement but limited by organ availability.
- Infections, cardiovascular disease, diabetes, and malignancies are complications of transplantation for which patients should be monitored.
- Inequities exist in access to transplantation and utilization of home dialysis modalities.

References

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