

Competency assessment in CRRT – core curriculum. G07

San Diego 2011

Hilton Bayfront

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**Austin Hospital
RMIT University
Australia**



Heamofiltration – Continuous Renal Replacement Therapy (CRRT) in ICU now for more than 25 years !



1996



2010

...more frequent use, multiple patients....

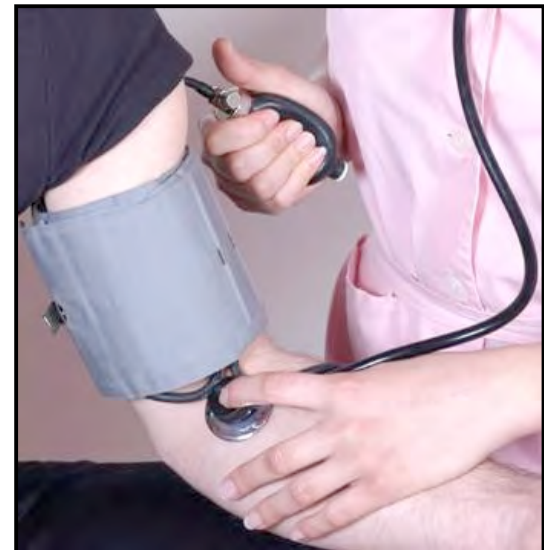


CRRT in Nursing schools ?

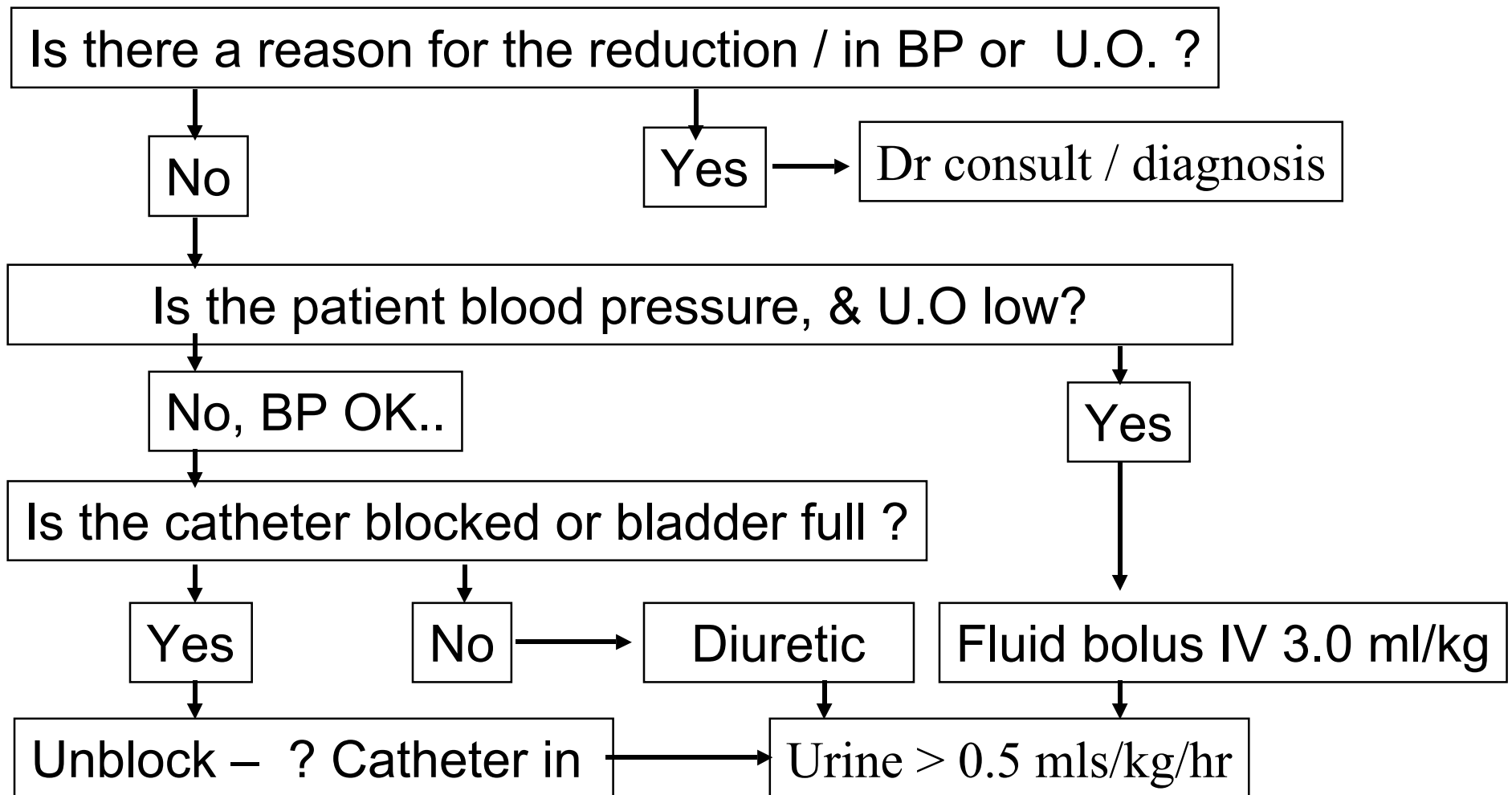
- ? Content/hours for ARF & CRRT
- Not yet considered 'life support'
- Loose link to clinical setting
- Hospital focus \Rightarrow machine training
- Assessment & credentialing undeveloped
- No clear curriculum for CRRT

Undergrads: Oliguria not useful on a ward....

- So what about a surrogate ?
- Blood pressure, a routine ward nursing observation
- But is it done ?

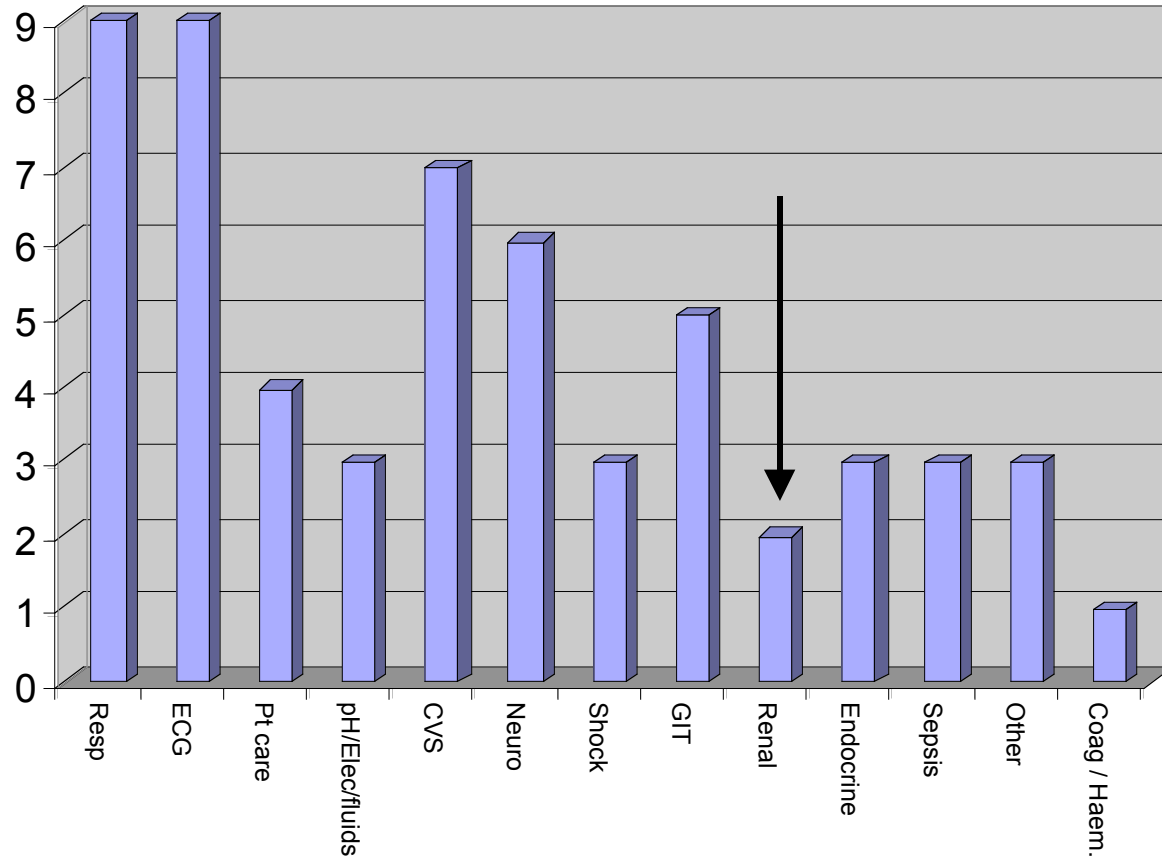


Oliguria and blood pressure : management flow chart



Post grad content - ICU

Post grad ICU subject hrs





CRRT nursing

- Often the sickest patients
- Nursing collaborative models vary
- Medical support also variable
- Safety reliance on machine design
- Learning by trial and error
- Mistakes occur



Fluids and fluids balance errors...

- Barletta J. et al 2006
 - Survey of pediatric programs
 - 31 responded
 - 18 med. errors, 2 fatal....!
 - 2 – Heparin prep.
 - 16 – prep. / mixing of fluids



Fluids and fluids balance errors...

- FDA notification. Aug. 23rd 2005 & Feb 2006...
www.fda.gov/cdrh/safety
 - Incorrect use of Prisma machine with excessive fluid removal
 - Failure of nurse to resolve alarm – ‘incorrect weight change detected’
 - Estimated 9 deaths, 11 serious injuries

Foothills Medical Centre, 2004

CRRT in elderly patient
K⁺ in dialysate – 53.6 mmol/L
Na⁺ - 5.9 mmol/L

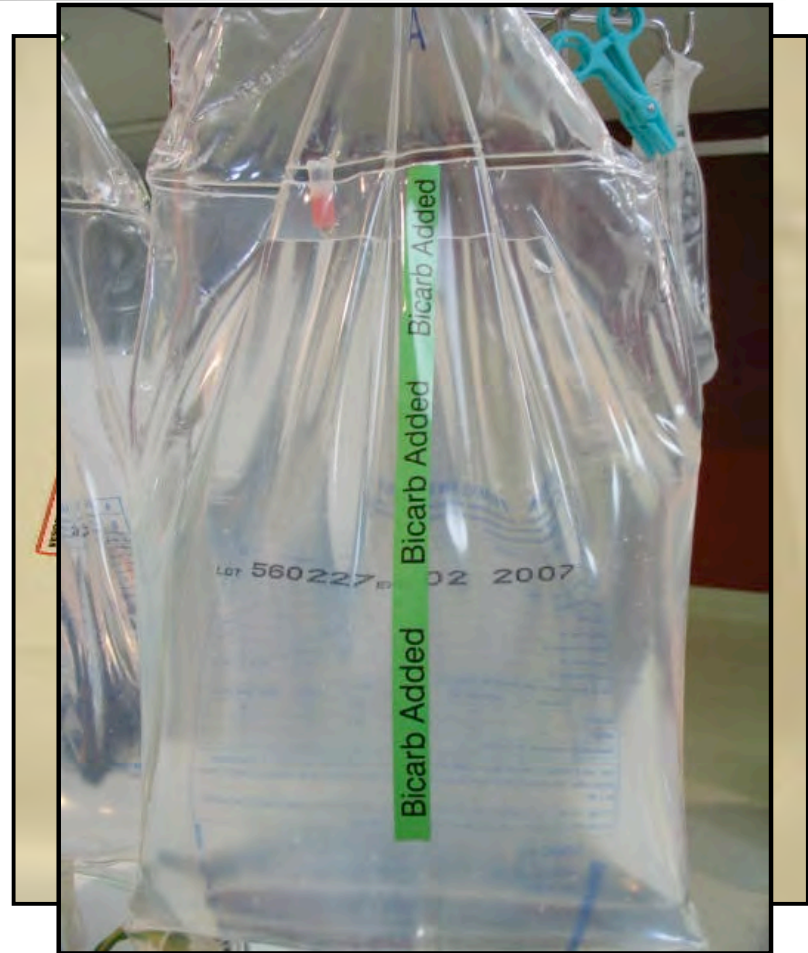
Central production pharmacy

Error continued despite a 4 step check process



My ICU – incident monitoring

- 5 hrs CVVHDF, no bicarbonate
- pH 7.36 to 7.23
- Nurse did not add bottle
- 2 part bag now
- Additive label used





Suggested key Curriculum : CRRT

A.R.F. and critical illness

Theory of solvent and solute removal

Techniques for CRRT

Fluids and fluid balance

Anticoagulation

Machines and E.C. circuit

Patient care

What is the 'world' doing with ARF in ICU ?

Acute Renal Failure in Critically Ill Patients A Multinational, Multicenter Study **JAMA 2005**

Shigehiko Uchino, MD

John A. Kellum, MD

Rinaldo Bellomo, MD

Gordon S. Doig, PhD

Hiroshi Morimatsu, MD

Stanislaw Morgera, MD

Muel Schetz, MD

Ian Tan, MD

Catherine Bouman, MD

Etiene Macedo, MD

Noel Gibney, MD

Ashita Tolwani, MD

Claudio Ronco, MD

for the Beginning and Ending
Supportive Therapy for the Kidney
(BEST Kidney) Investigators

Context Although acute renal failure (ARF) is believed to be common in the setting of critical illness and is associated with a high risk of death, little is known about its epidemiology and outcome or how these vary in different regions of the world.

Objectives To determine the period prevalence of ARF in intensive care unit (ICU) patients in multiple countries; to characterize differences in etiology, illness severity, and clinical practice; and to determine the impact of these differences on patient outcomes.

Design, Setting, and Patients Prospective observational study of ICU patients who either were treated with renal replacement therapy (RRT) or fulfilled at least 1 of the predefined criteria for ARF from September 2000 to December 2001 at 54 hospitals in 23 countries.

Main Outcome Measures Occurrence of ARF, factors contributing to etiology, illness severity, treatment, need for renal support after hospital discharge, and hospital mortality.

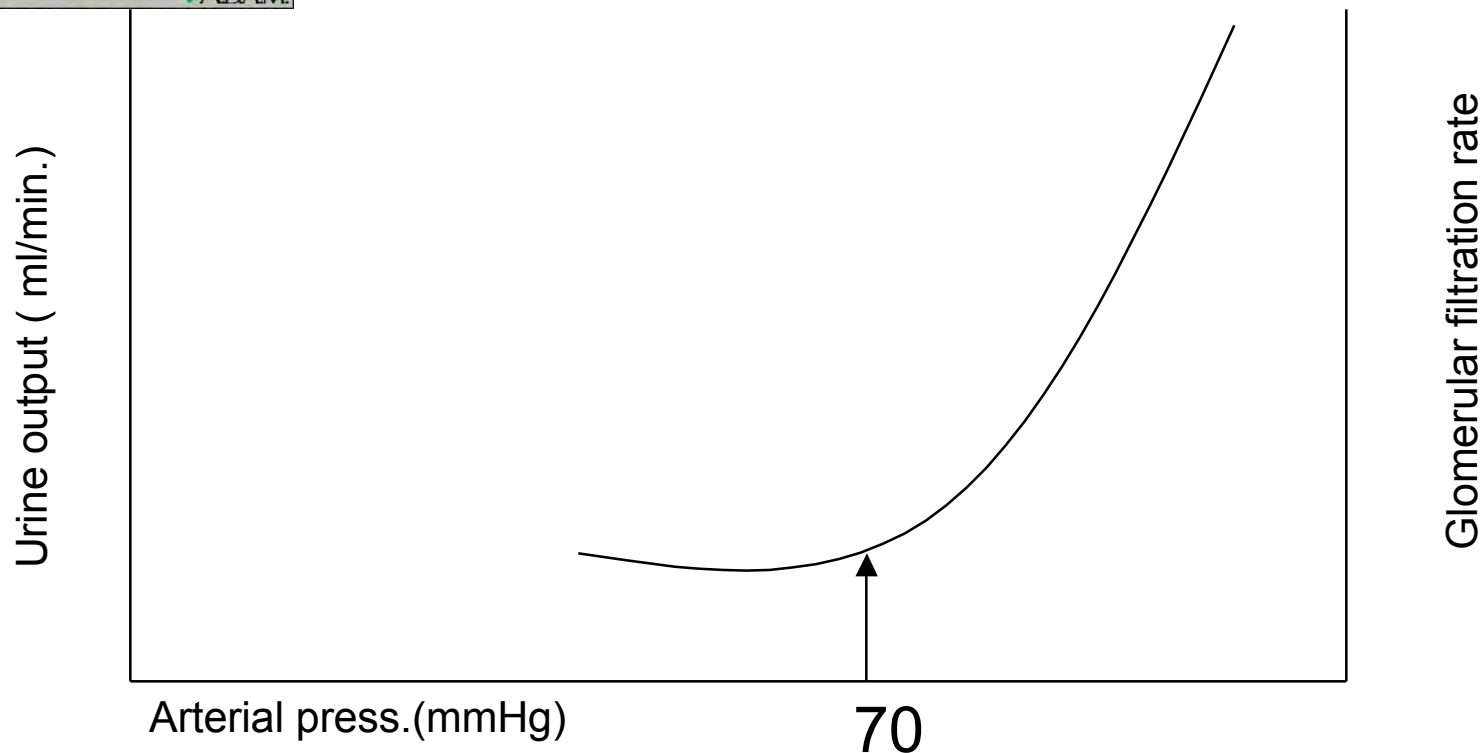
Results Of 29 269 critically ill patients admitted during the study period, 1738 (5.7%; 95% confidence interval [CI], 5.5%-6.0%) had ARF during their ICU stay, including 1260 who were treated with RRT. The most common contributing factor to ARF was septic shock (47.5%; 95% CI, 45.2%-49.5%). Approximately 30% of patients had preadmission renal dysfunction. Overall hospital mortality was 60.3% (95% CI, 58.0%-



Major Findings: Incidence

- Severe ARF in 1738 of 29,269 patients screened (**5.7%**)
- **30%** have CKD before ICU admission
- RRT is applied commonly (**4.3%**)
- Mortality is high: **60.3%**
- Dialysis dependence at hospital discharge for survivors: **13.8%**

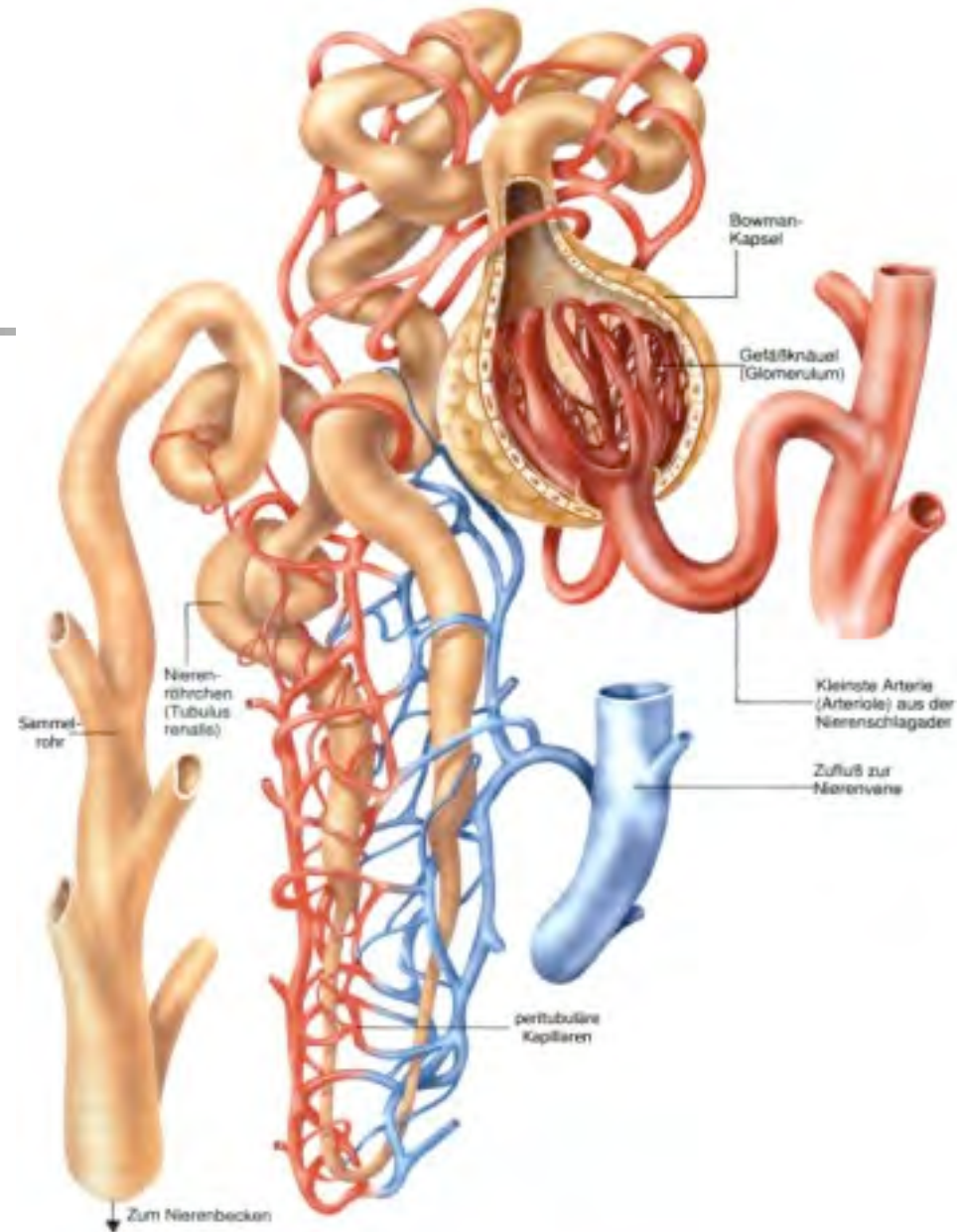
Renal Blood flow : ~ 25 % of the cardiac output
1250 ml /min
(but Kidneys only 0.4 % of body weight)
Strong relation b/w RBF and GFR



Functional units.



Glomerulus & Bowman's Capsule structures



<http://www.youtube.com/watch?v=glu0dzK4dbU>



Kidney functions : Summary

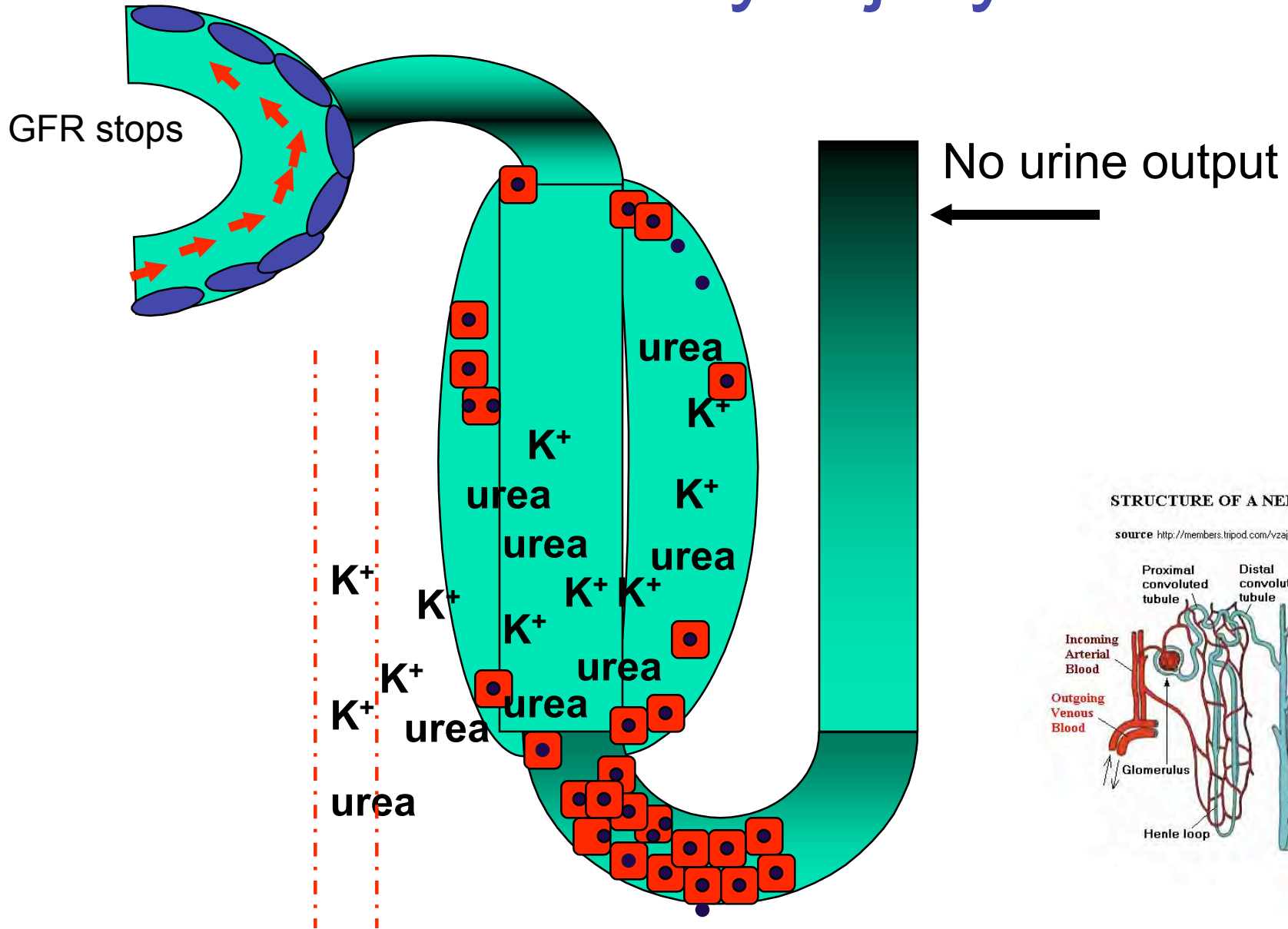
- Removal of metabolic wastes, 'foreign chemicals'
- Water balance and electrolyte balance
- Regulation of osmolarity
- Acid – base balance (pH)
- Arterial pressure regulation
- Secretion, metabolism, hormone excretion



The kidney and disease.

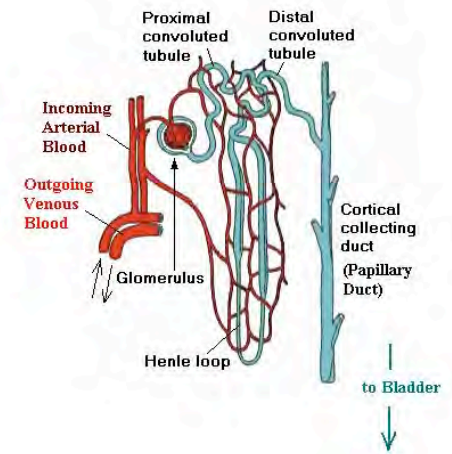
- Acute glomerular nephritis
- Diabetic nephropathy
- Cystic Kidney disease
- Nephrotic syndrome
- Tubular diseases - damage

Acute kidney injury - failure.

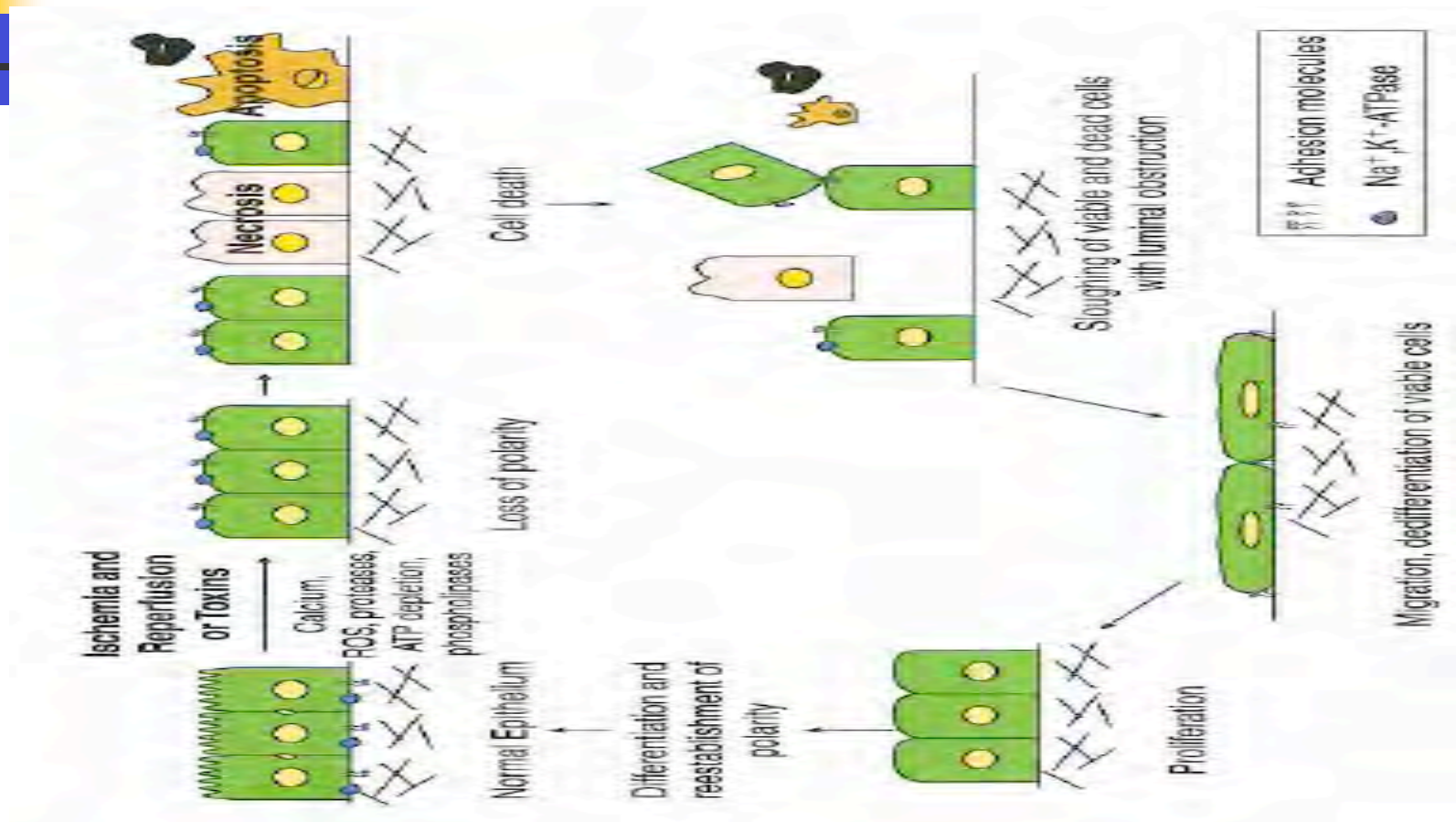


STRUCTURE OF A NEPHRON

source <http://members.tripod.com/vzajic/nephron.jpg>



Tubular epithelial response to ischaemia, toxins (injury and repair)



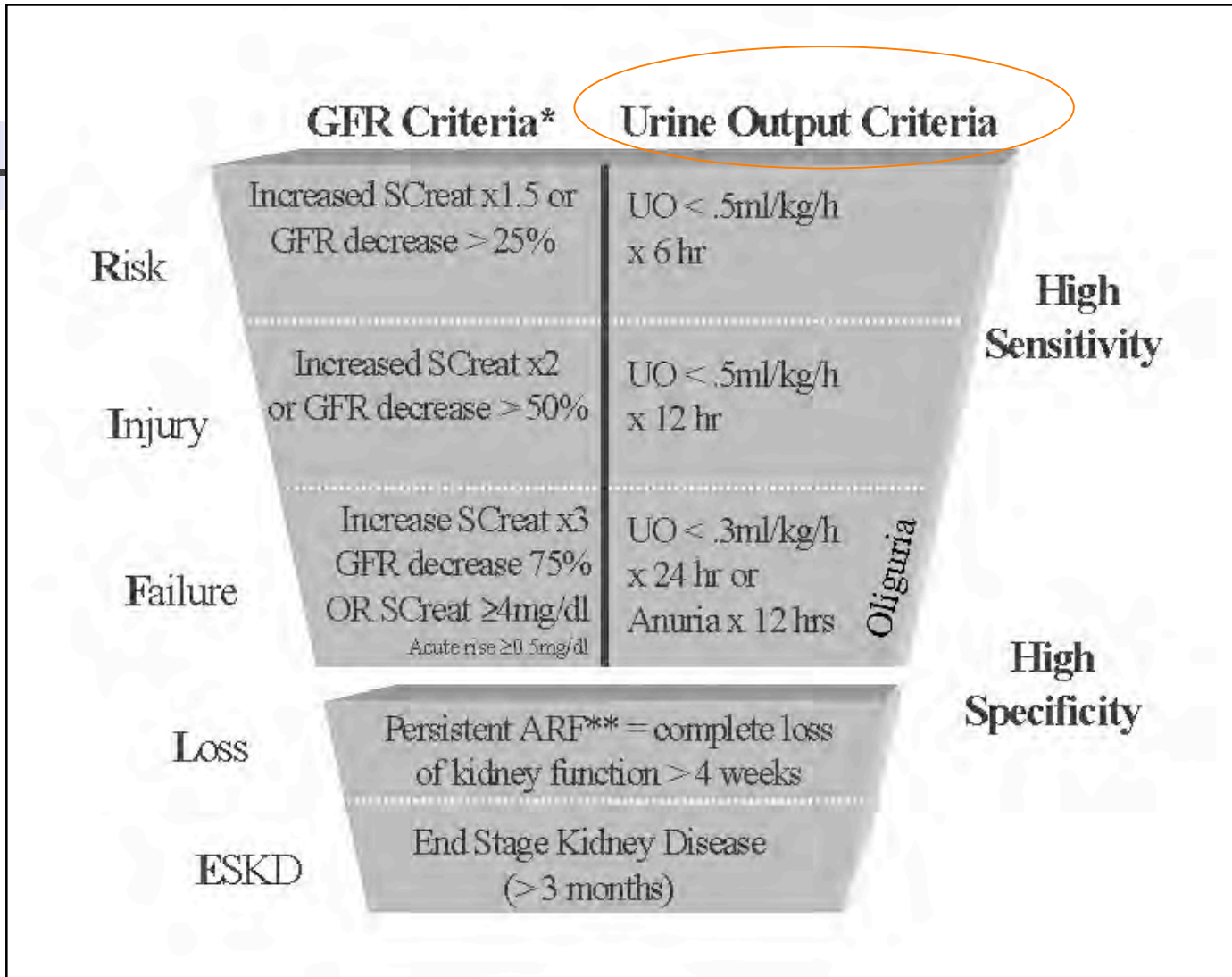
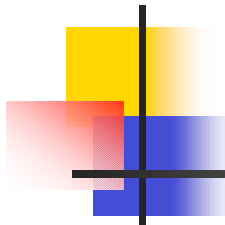
L Gunaratnam & J Bonventre; Chapt 32 in Kidney Diseases
5th edn. Greenberg A, editor, 2009



Acute Kidney Injury (AKI).

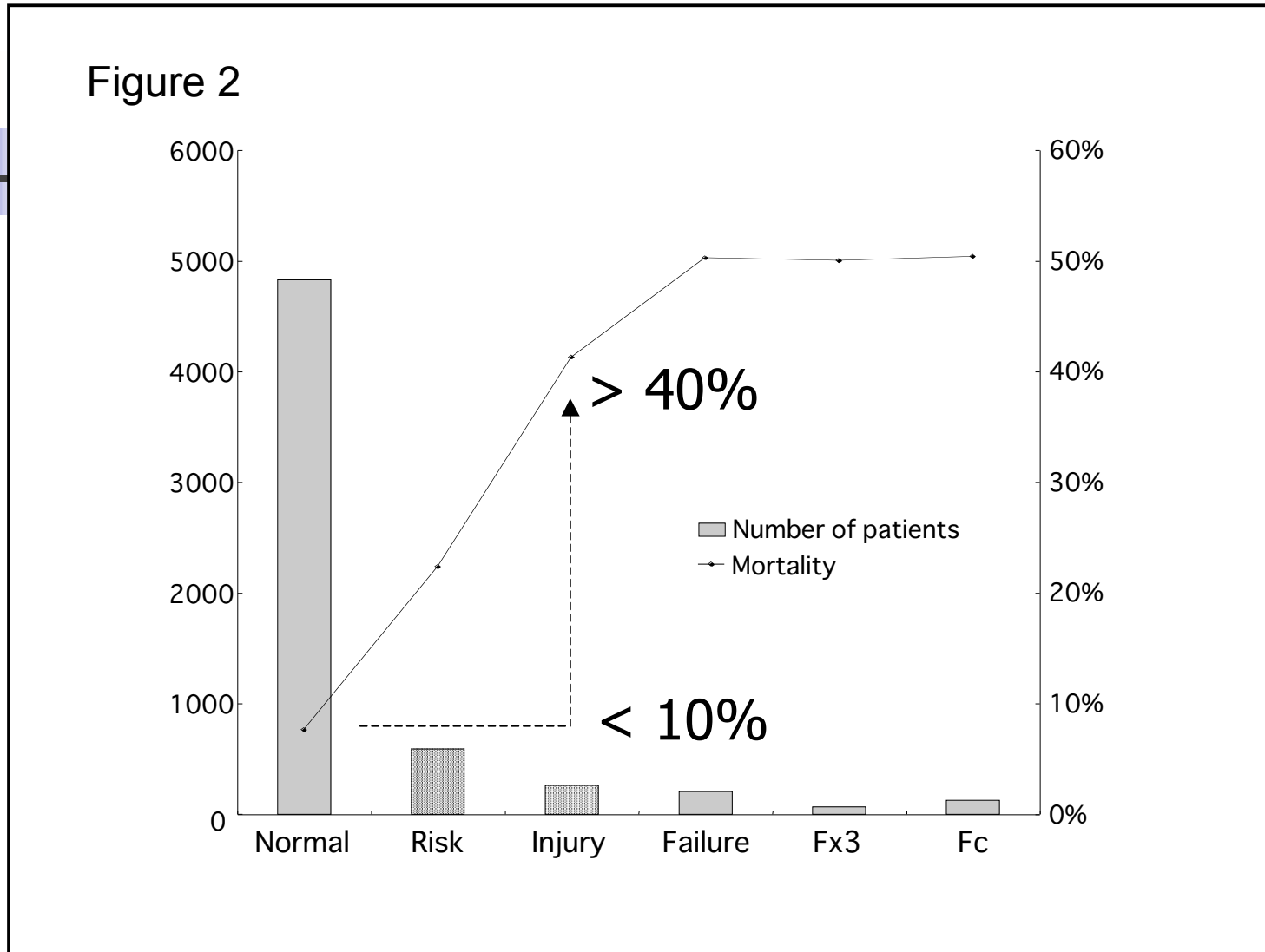
- Acute renal failure – many definitions
- New term – AKI, encompasses the entire spectrum of the syndrome, minor changes in function to need for renal replacement therapy.
- ‘RIFLE’ criteria provides a uniform definition of AKI

RIFLE criteria



ADQI, Crit Care 2004 (8) 204-212

Validation of RIFLE



Uchino and Bellomo et al Crit Care Med. 34(7) 2006



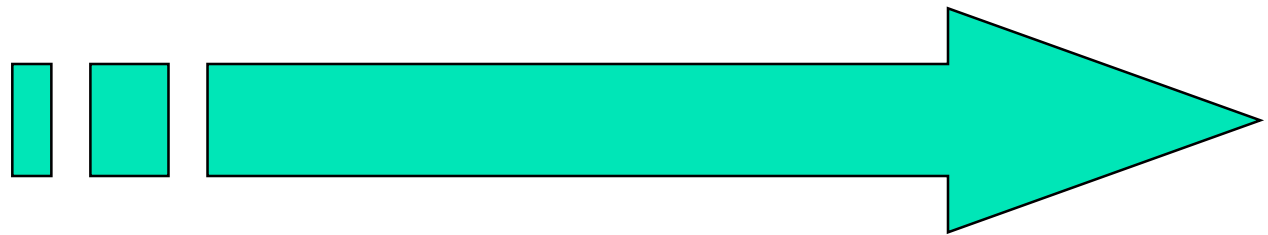
Acute Renal Failure...Management.

- Fluid resuscitation.
- BP maintenance. MAP > 75 mmHg.
- Nutrition - protein rich.
- Electrolyte control.
- Correction of acidosis, anaemia, infection.
- Modify drugs that are nephrotoxic.
- Stress ulcer prophylaxis.
- Renal replacement therapy. Early and aggressive.

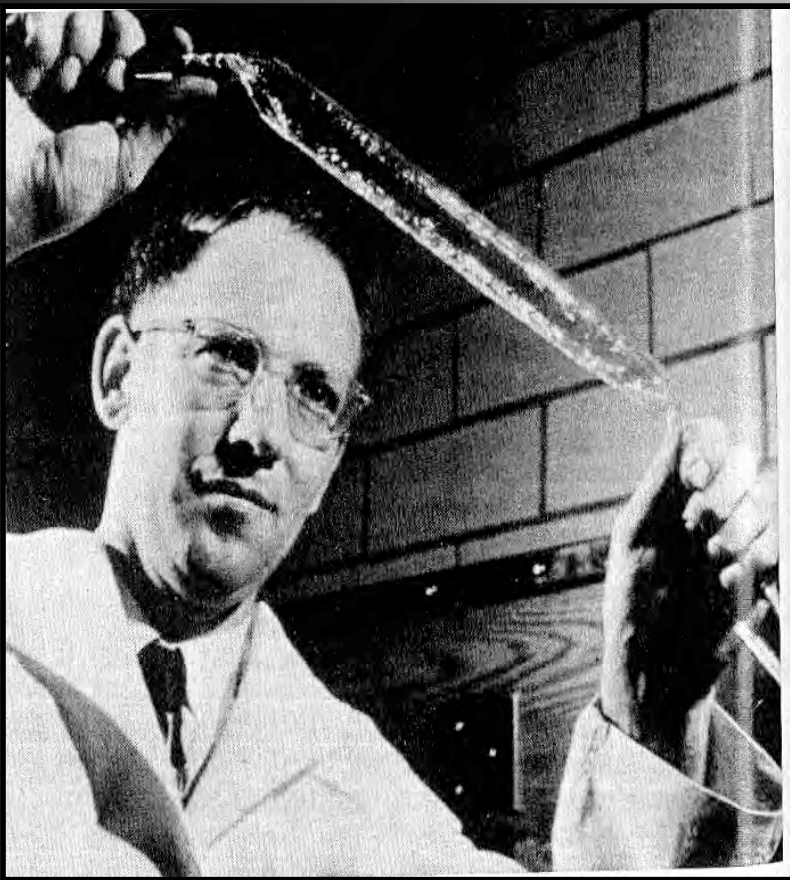
Renal Replacement techniques



- Peritoneal dialysis
- Haemodialysis
- Continuous Renal Replacement Therapy (CRRT) Hemofiltration



History of Dialysis

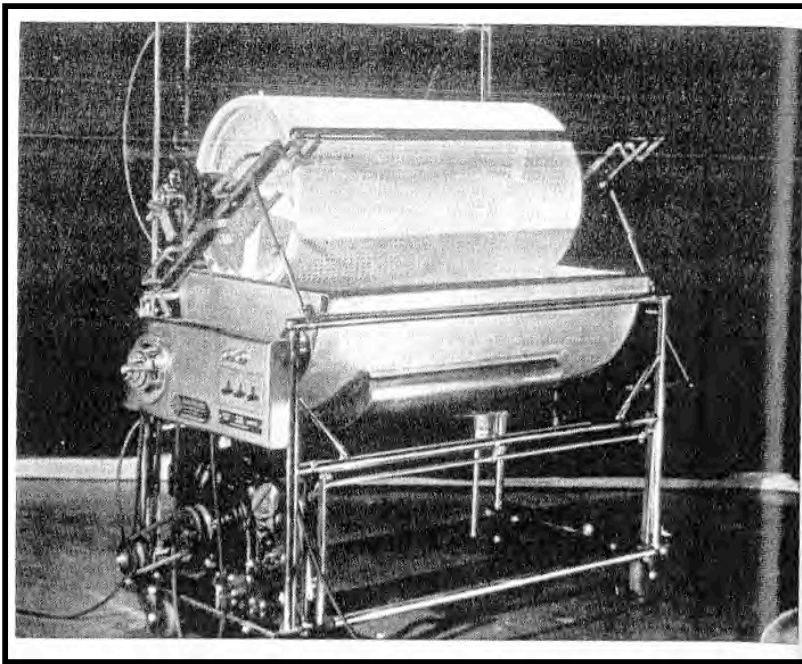


Sausage casing membrane ; Identified by William Thalheimer for a dialysis membrane

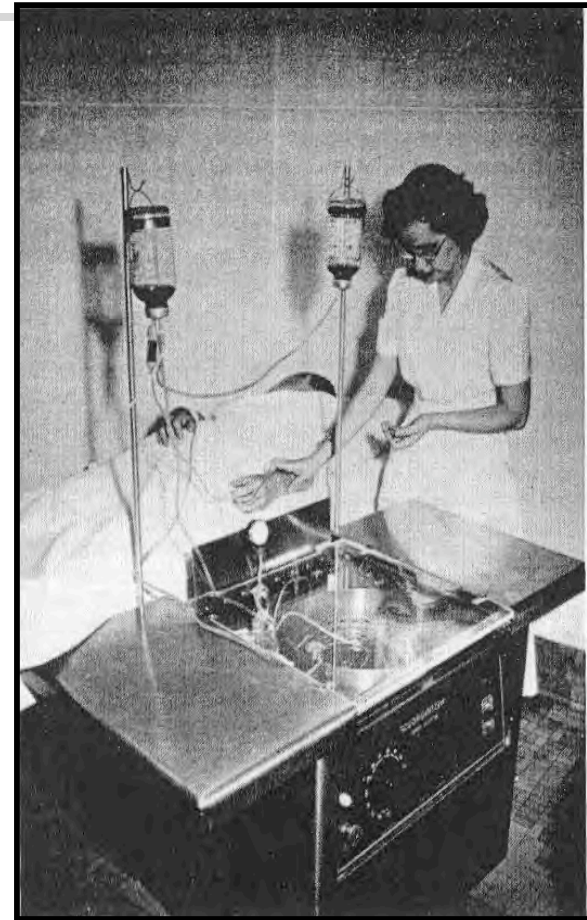
Cellulose and acetate used in the food and packaging industry.

Strong, tolerates pressure and could be sterilised.

History of Dialysis



The Allis Chalmers Company
Rotating drum Artificial kidney in
Milwaukee, Wisconsin



Vertical drum Artificial Kidney by Westinghouse
Corporation, USA

Different settings : CRRT and IHD

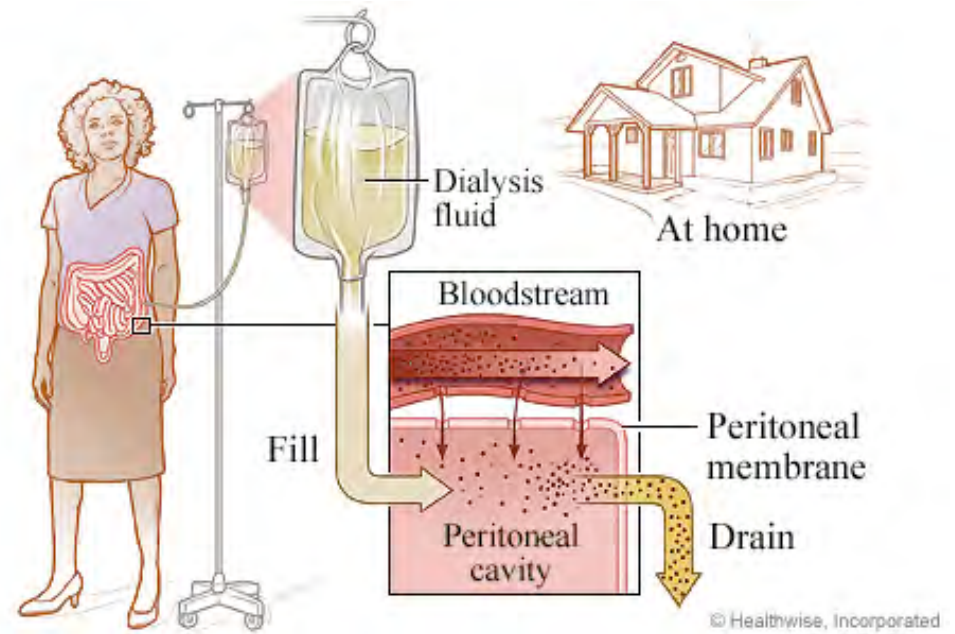
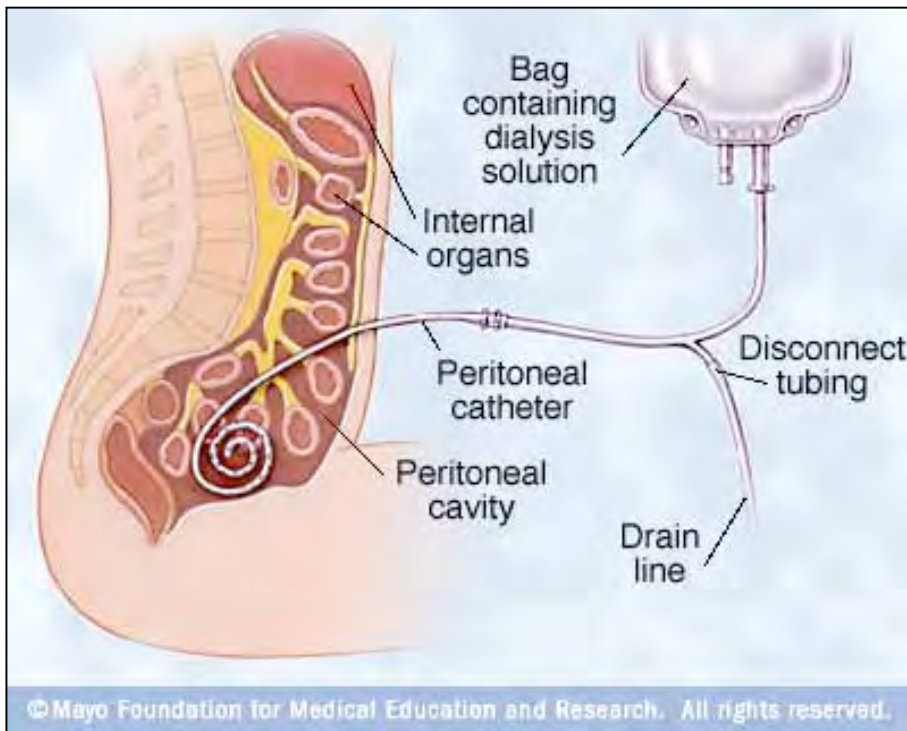


Dialysis clinic - outpatients



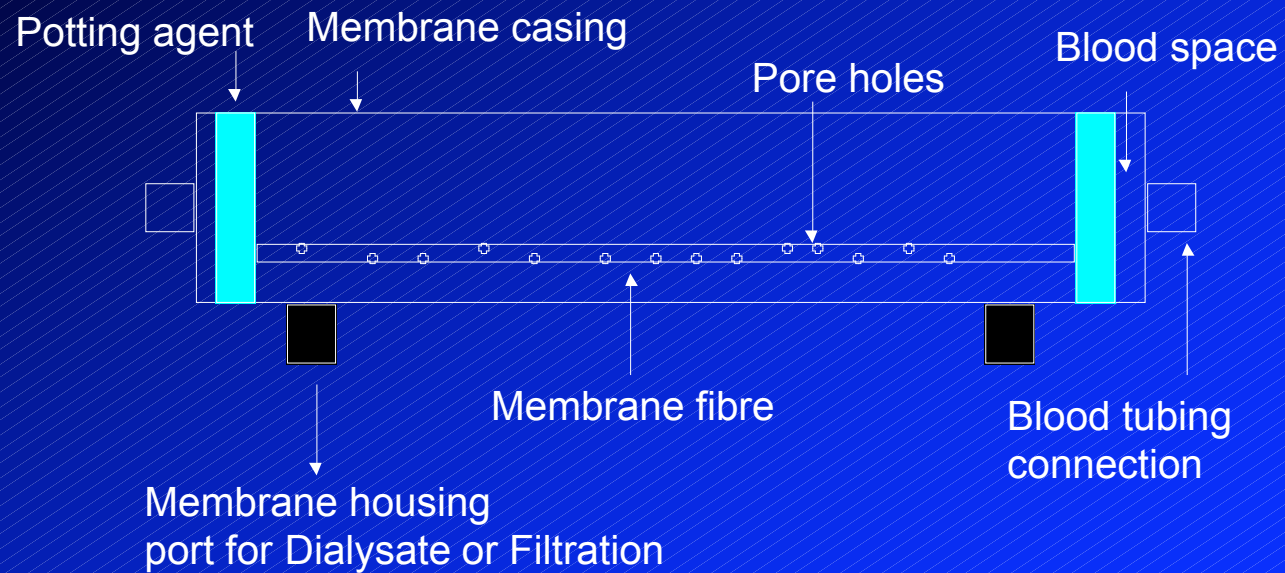
Intensive Care - inpatients

Peritoneal Dialysis

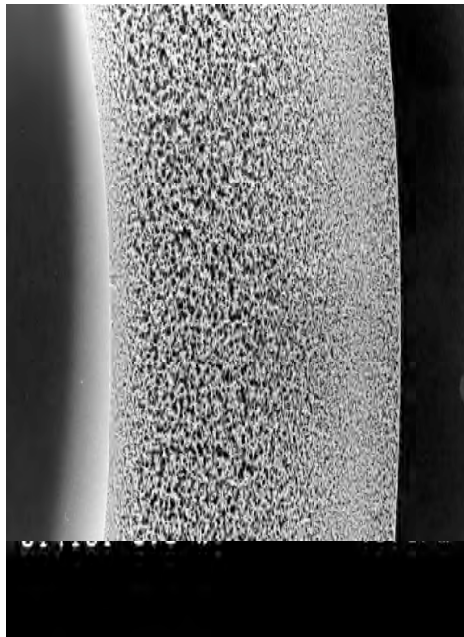


Membrane is main 'engine' for CRRT.

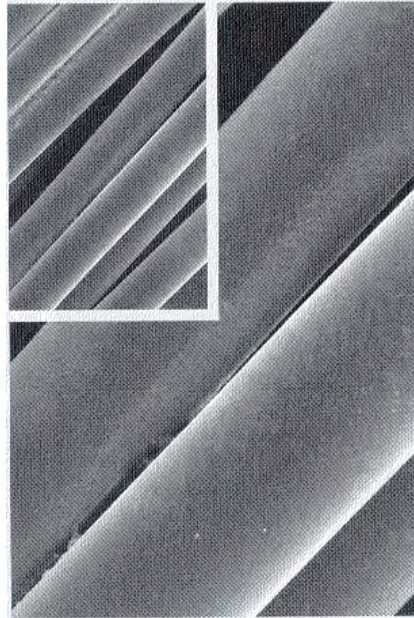
Membranes for CRRT



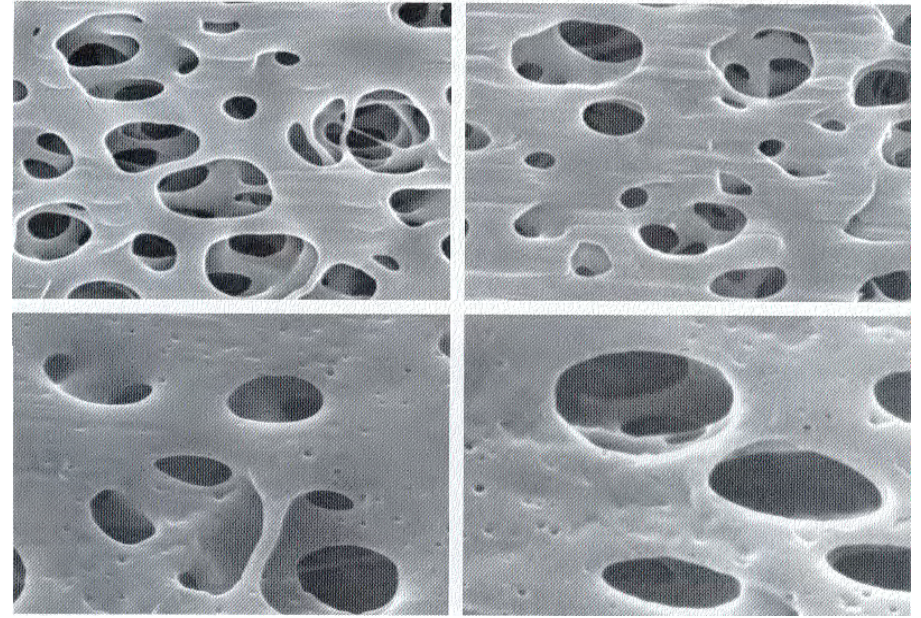
Membrane structure



Fiber cross section;
sponge structure.



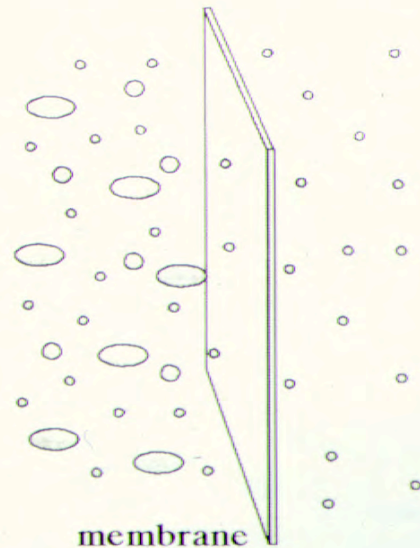
Fibers



Outer side wall of different
Polysulfone, arylethersulfone
& polyamide-s membranes

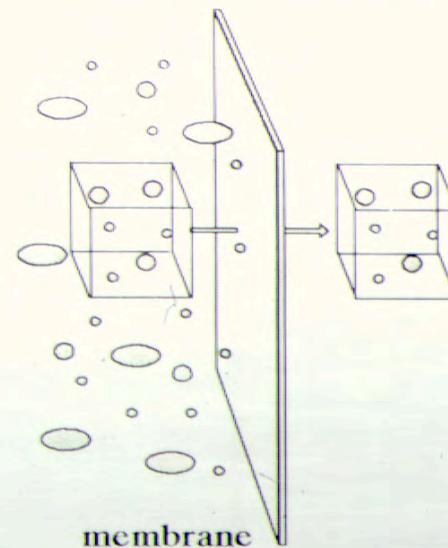
MECHANISMS OF SOLUTE REMOVAL

DIFFUSION



Driving Force = Concentration Gradient

CONVECTION

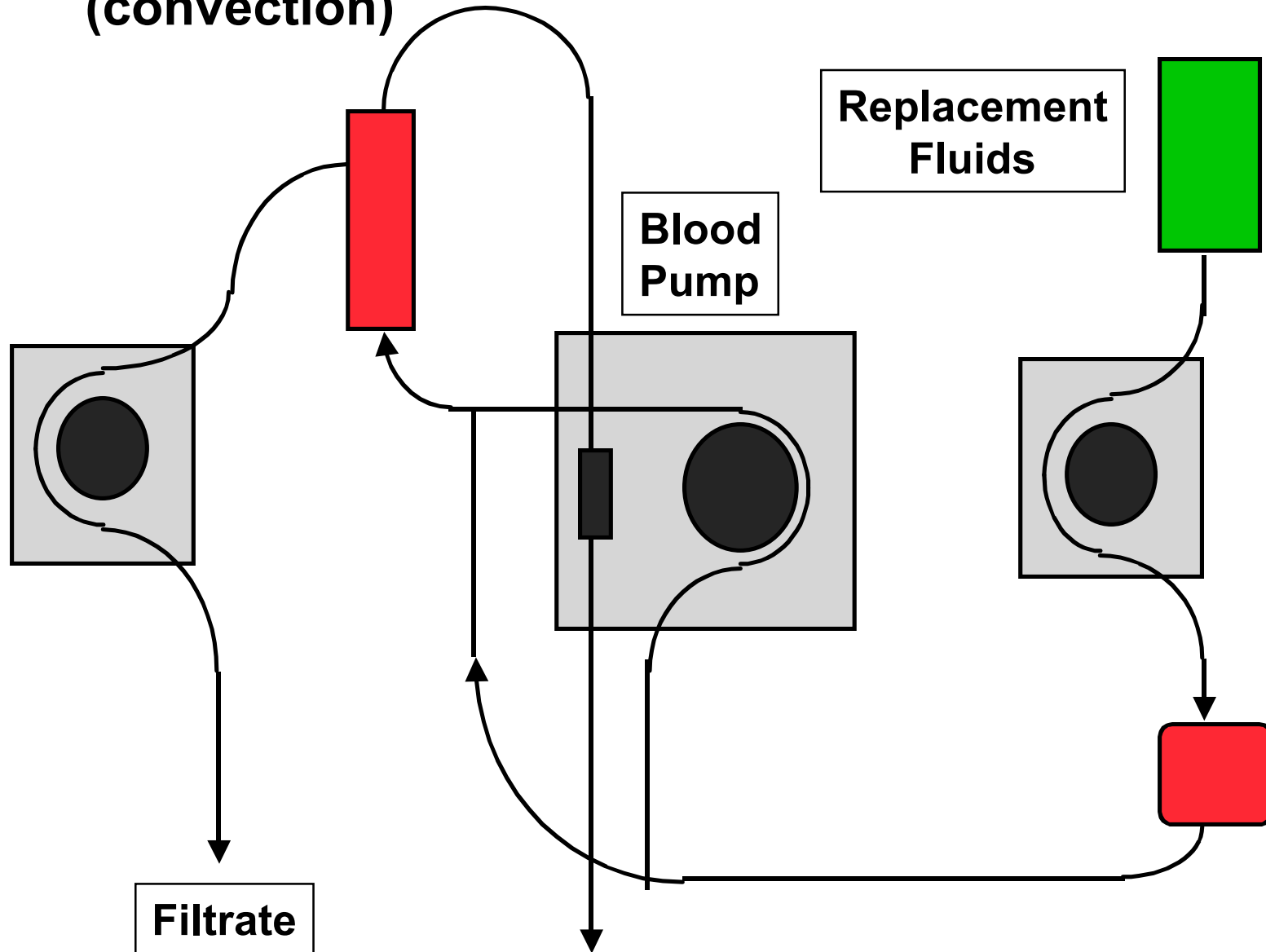


Driving Force = Pressure - Ultrafiltration

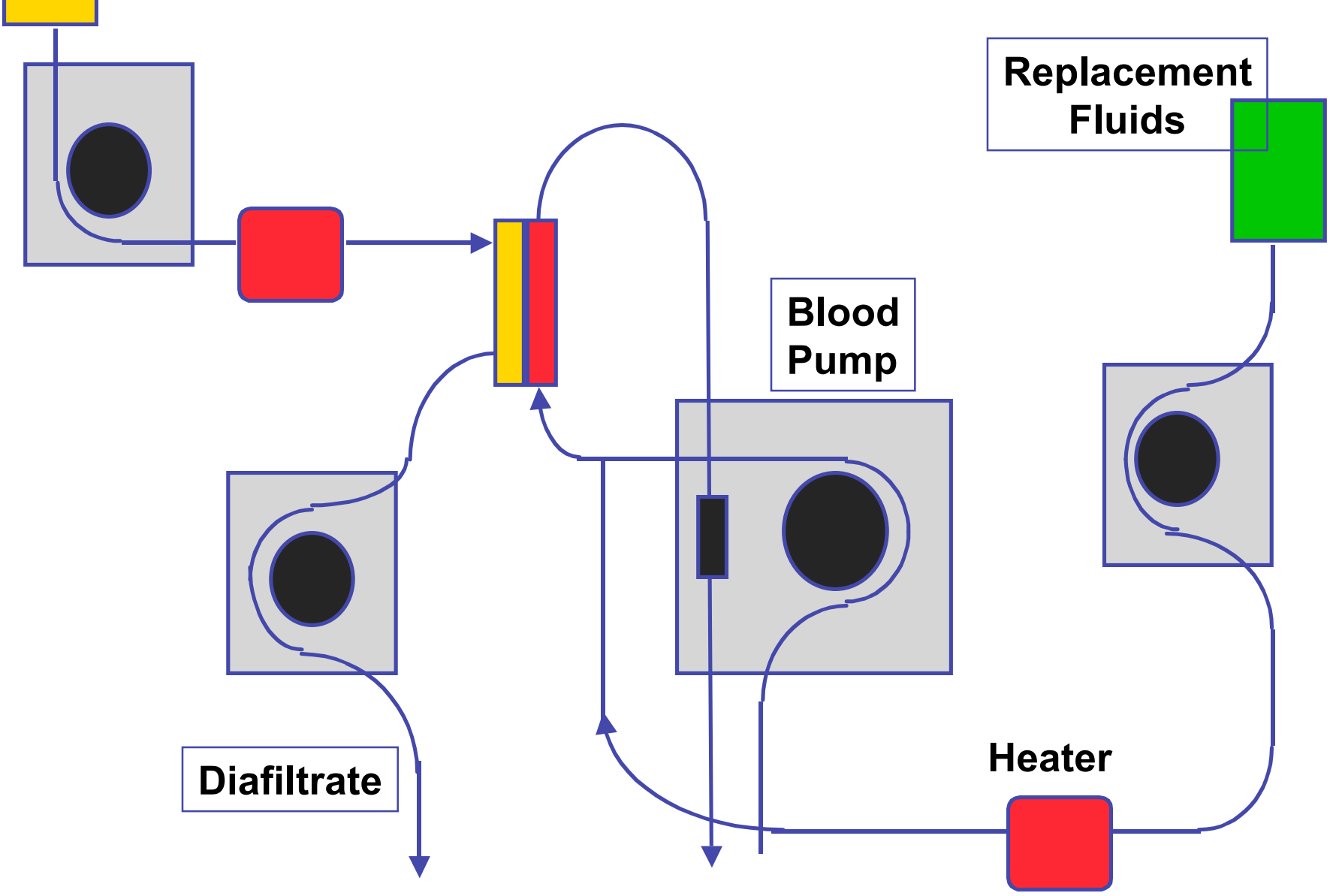
Exchange of wastes
Across membrane by
Concentration gradients....

Plasma water removal
with wastes dissolved in
the water...

CVVH – plasma water removal & replacement (convection)



Dialysate **CVVHD(F)** - diffusion & convection



Renal Support Technique

Intensity

Diffusion

**IHD,
CVVHD**

Convection + Diffusion

CVVHDF

Convection

CVVH

Duration

Fluid Balance

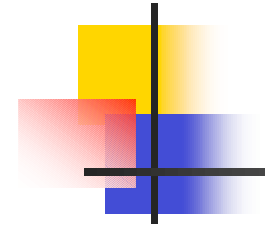
Solute Clearance



Fluids

- Provide a fluid replacement for plasma water removed – convection (CVVH)
- Provide a fluid for solute (waste) removal – diffusion (CVVHD)
- Correct electrolytes and acid base bal.

Commercial fluids : Australia



5000ml	K	gluc	buff	pH	made	cost	Co.
Hemosol Gambro	1.0	0	Bic	?	UK	\$28.00	Gambro
Gambro_(HF1) Gambro	1.0	10	Lact	5-5.4	Aus.	\$15.45	Gambro
Edwards	1.0	0	Citrate	5-6.5	Aus.	\$39.17	Baxter
Accusol	4.0	0	Bic	7.4	USA	\$?	Baxter

CRRT solutions

Lactate solution

Acetate solution

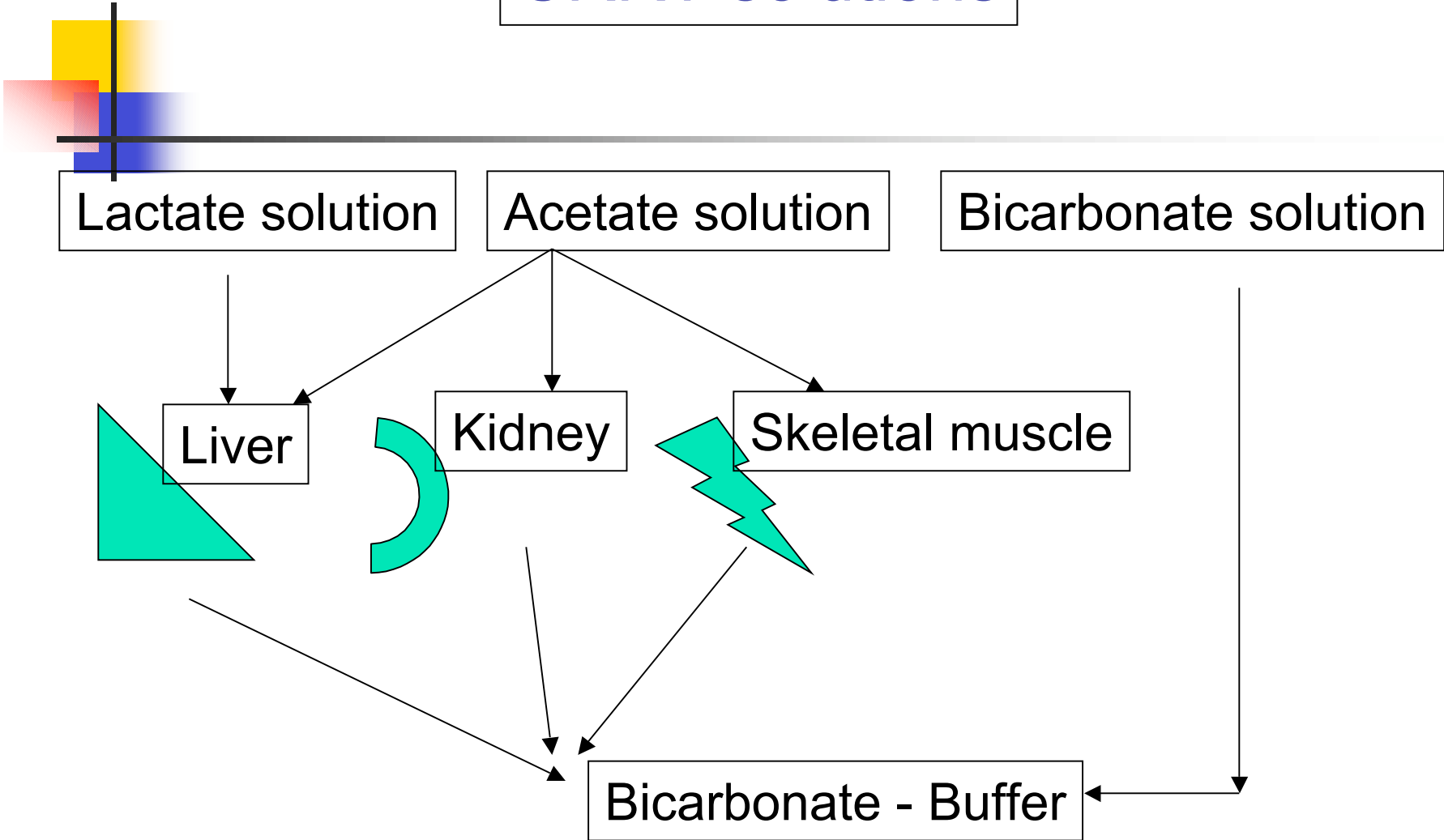
Bicarbonate solution

Liver

Kidney

Skeletal muscle

Bicarbonate - Buffer





Fluids settings - examples

- Fixed rates – how to achieve fluid loss
- Increase fluid removal or decrease fluid replacement ?
- Anticoag volumes
- Patient balance and machine balance ?

Charting

Time	Urine	Naso Gastric	FLEXISEAL	CRRT(-)	HOURLY TOTAL OUT	Progressive Total OUT	Overall 6/24 Progressive Balance	CRRT					
								Replacement/Dialysate	Anticoag	Input	Output	Hourly Balance	Progressive CRRT Balance
A				100	100	100		1140	-	2270	2370	-100	
Z				100	100	200		1140	-	2270	2370	-100	
S				100	100	300		1140	-	2270	2370	-100	
R				100	100	400		1140	-	2270	2370	-100	
I				100	100	500		1140	-	2270	2370	-100	
C		280 ^(R)	100/850 NEW BAG	100	200	700	-8	1140	-	2270	2370	-100	
				100	100	800		1140	-	2270	2370	-100	
				100	100	900		1140		2280	2380	-100	
				100	100	1000	+140	1140		2280	2380	-100	
				100	100	1100		1140		2280	2380	-100	
				100	100	1200		1140		2280	2380	-100	
		Discarded - Fresh blood 700		100	800	2000		1140		2280	2380	-100	
R A L		700	100	1200		2000	-457						
				100	100	2100		1140		2280	2380	-100	
				100				1400	-	2280	2380	-100	
		free drain						1400	-				

Charting

				62	72	72 ✓	-71	479		479	541	62	-62
				246	271	343 ✓	-341	1283	40	1323	1569	246	-308
				239	254	597 ✓	-594	1727	40	1767	2006	-239	-547
				215	227	824 ✓	-720	1711	40	1751	1966	215	-762
				184	199	1023 ✓	-918	1711	40	1811	1995	184	-946
				236	249	1272 ✓	-1116	1760	40	1800	2036	236	-1182
				170	183	¹⁴⁵⁵ 1290	-1298	1641	37	1678	1848	170	-1352
				244	263	¹⁷¹⁸ 1553	-1301	⁹¹⁷ / ₉₂₃	42	1882	2126	-244	-1596
				57	71	¹³⁸⁷ 1674	-1371	⁹²⁶ / ₉₂₃	40	1889	1946	-57	-1653
				34	46	¹⁸³⁵ 1670	-1411	⁹⁰⁸ / ₉₃₂	40	1880	1914	-34	-1687
				232	244	²⁰⁷⁹ 1714	-1647	⁸⁶⁴ / ₈₇₀	41	1783	2015	-232	-1919
				269	291	²⁶⁷⁰ 2205	-1627	⁷⁸⁶ / ₈₁₇	37	1640	1909	-269	-2188
				2188		2370	-1627	1246	437	19683	2188		-2188
				235	277	2647	-1896	⁸⁹² / ₈₃₅	39	1705	1940	-235	-2423
				272	292	2939	-2180	⁸⁰⁰ / ₁₇₂₃	40	1763	2035	-272	-2695
				197	224	3163	-2394	1712	40	1752	1949	-197	-2892

v Lasix

Monday, 6/9/2010

David CASSAR 876698

Previous day's balance -185 (ml)

Cumulative balance -15.082 (ml)

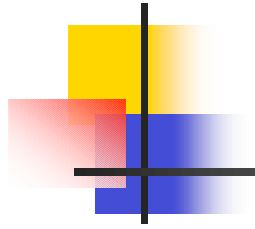
TIME	INPUT (ml)										OUTPUT (ml)										Time		Input		Output		Balance		CRRT		
	Column labels	HORADREXALINE	HARTMANN'S D&F	K2H2PO4	GANGCIL OVR	ALBUMEN	ACTRAPID	PRBC	PANTOPRAZOLE	NG MEDS	ENTERAL	ORAL	HOURLY TOTAL IN	Progressive Total IN	URINE	NG ASPIRATE DRAIN	NG ASPIRATE RET.	BOWEL	PLEURAL TAP	CRRIT	HOURLY TOTAL OUT	Progressive Total OUT	BOWELS OPEN?	Hourly Balance	Overall Progressive Balance	Machine Loss	Anticoagulant	Hourly Balance	Progressive CRRT Balance	Exchange Rate	
01:00								10		65	75	75								-35	35	35	<input type="checkbox"/>	40	40	35		-35	-35	2000	
02:00							50	10		65	125	200								-102	102	102	<input type="checkbox"/>	23	63	102		-102	-137	2000	
03:00							100	10		65	175	375								-84	84	221	<input type="checkbox"/>	91	154	84		-84	-221	2000	
04:00							150	10	250	65	475	850								-100	100	321	<input type="checkbox"/>	375	529	100		-100	-321	2000	
05:00								10		65	75	925								-141	141	462	<input type="checkbox"/>	-66	463	141		-141	-462	2000	
06:00								10		65	75	1000								-151	151	613	<input type="checkbox"/>	-76	387	151		-151	-613	2000	
07:00								10		65	75	1075			40					-146	186	799	<input type="checkbox"/>	-111	276	146		-146	-799	2000	
08:00		20						10	60	65	155	1230				10				-148	148	947	<input type="checkbox"/>	7	283	148		-148	-907		
09:00		50						10		65	125	1355								-153	153	1100	<input type="checkbox"/>	-28	255	153		-153	-1060		
10:00		70						10	30	65	175	1530								-145	145	1245	<input type="checkbox"/>	30	285	145		-145	-1205		
11:00								10		65	75	1605								-70	70	1315	<input type="checkbox"/>	5	290	70		-70	-1275		
12:00								10	40	30	80	1685				15				0	0	1315	<input type="checkbox"/>	80	370		0	-1275			
13:00								10		65	75	1760								0	0	1315	<input type="checkbox"/>	75	445		0	-1275			
14:00								10	30	65	105	1865								0	0	1315	<input type="checkbox"/>	105	550		0	-1275			
15:00								10		65	75	1940								-1	1	1316	<input type="checkbox"/>	74	624	1		-1	-1276		
16:00								10		65	75	2015								-138	138	1454	<input type="checkbox"/>	-63	561	138		-138	-1414		
17:00				130				10		65	205	2220								-153	153	1607	<input type="checkbox"/>	52	613	153		-153	-1567		
18:00								10		65	75	2295								-148	148	1755	<input type="checkbox"/>	-73	540	148		-148	-1715		
19:00								10		65	75	2370								-146	146	1901	<input type="checkbox"/>	-71	469	146		-146	-1861		
20:00								10	240	65	315	2685			60					-160	220	2121	<input type="checkbox"/>	95	564	160		-160	-2021		
21:00								10		65	75	2760								-148	148	2269	<input type="checkbox"/>	-73	491	148		-148	-2169	2000	
22:00		70						10		65	145	2905								-145	145	2414	<input type="checkbox"/>	0	491	145		-145	-2314	2000	
23:00								10		65	75	2980								-148	148	2562	<input type="checkbox"/>	-73	418	148		-148	-2462	2000	
24:00								10	60	65	135	3115								-145	145	2707	<input type="checkbox"/>	-10	408	145		-145	-2607	2000	
24 hr totals		210		130			300		240	710	1525			100	25										2607						

Hide Print CRRT Close



Goals of anticoagulation

- Maintain patency and function of extracorporeal circuit
- Minimise activation of coagulation factors or platelets
- Avoid complications
 - Bleeding
 - Drug specific
- Intentionally anticoagulate patient when indicated



Anticoagulation

Nil

Optimize circuit
'mechanics'

Systemic

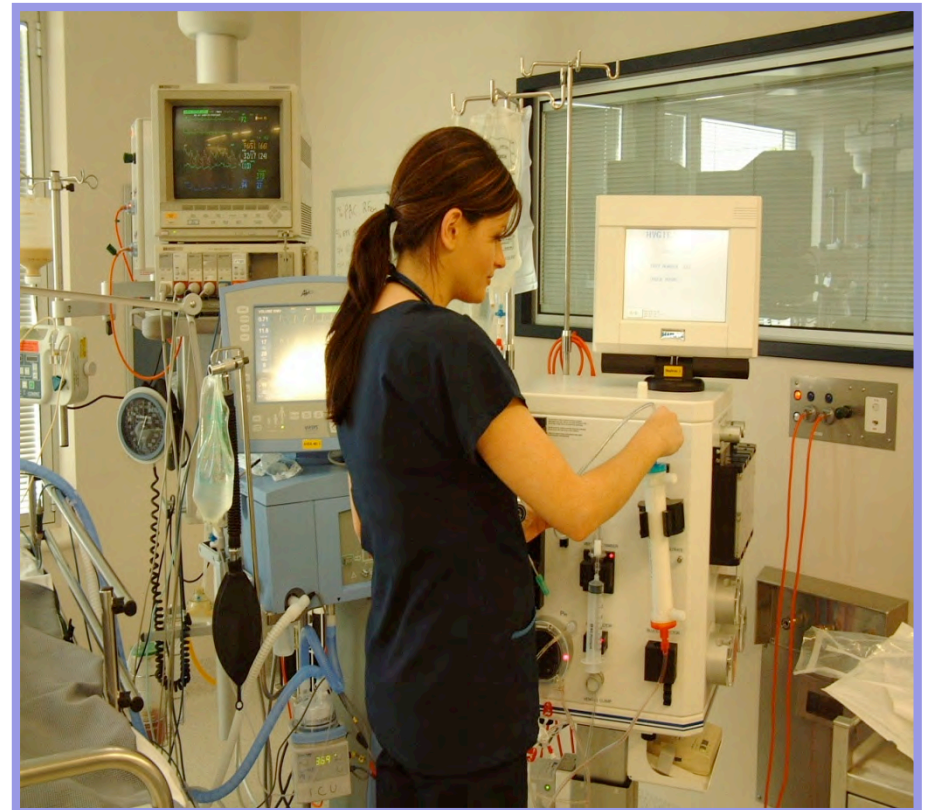
Heparin (UF)
LMWH
Heparinoids
Thrombin antagonists
Platelet inhibitors
Combinations of above

Regional

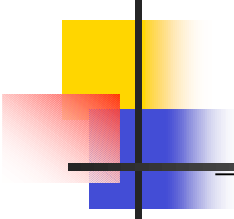
Heparin & Protamine
Citrate & Ca⁺⁺

What are the Alternatives ?

- Unfractionated heparin(UFH)
- Citrate / calcium ('RA')
- Heparin / protamine ('RA')
- Low molecular weight heparins (LMWH)
- Prostaglandins
- Others
 - Hirudin, Nafamostat
- None!
- Non thrombogenic circuits and filters

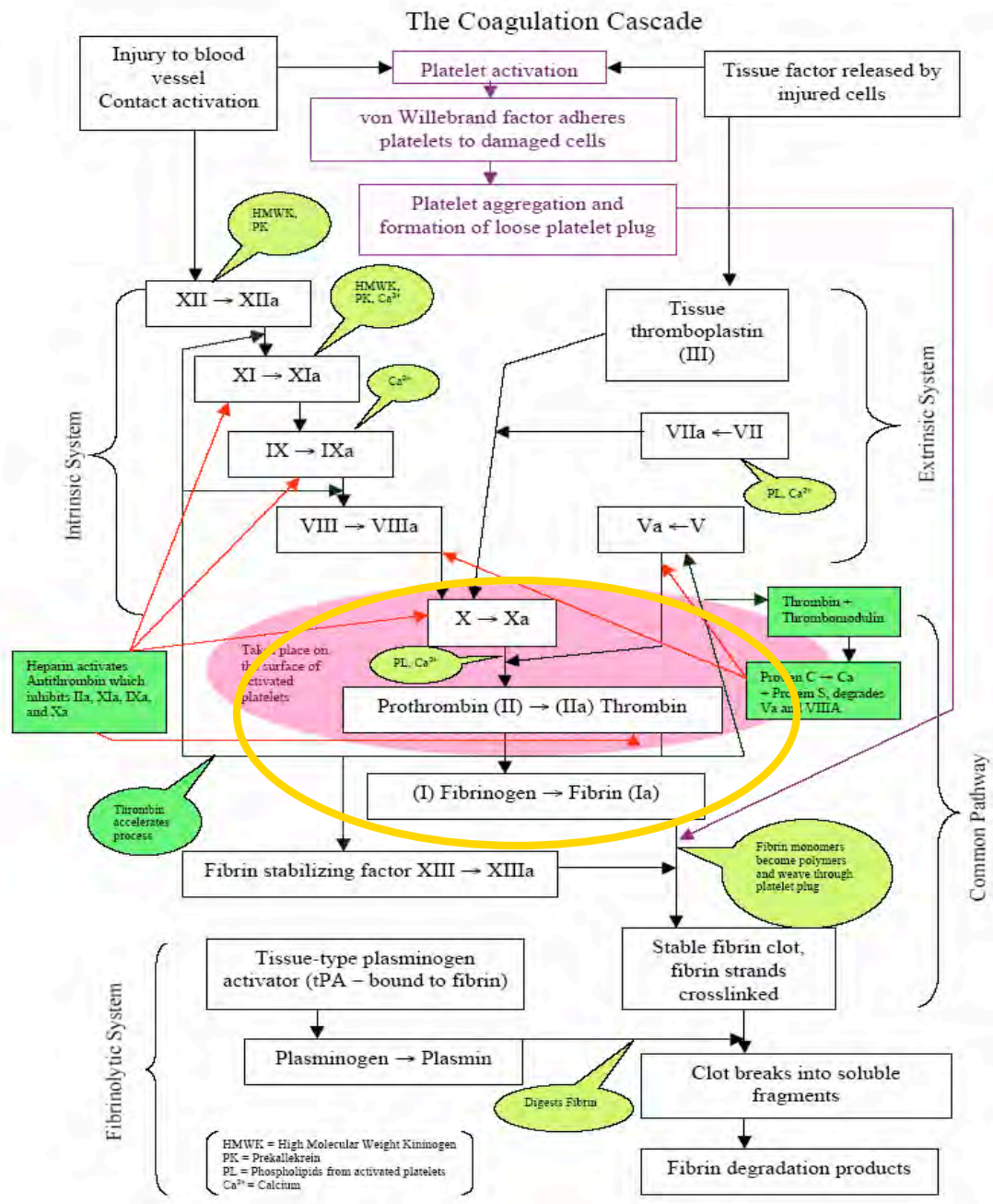
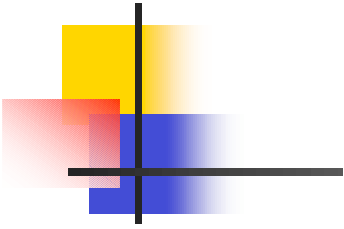


Anticoagulation around the world

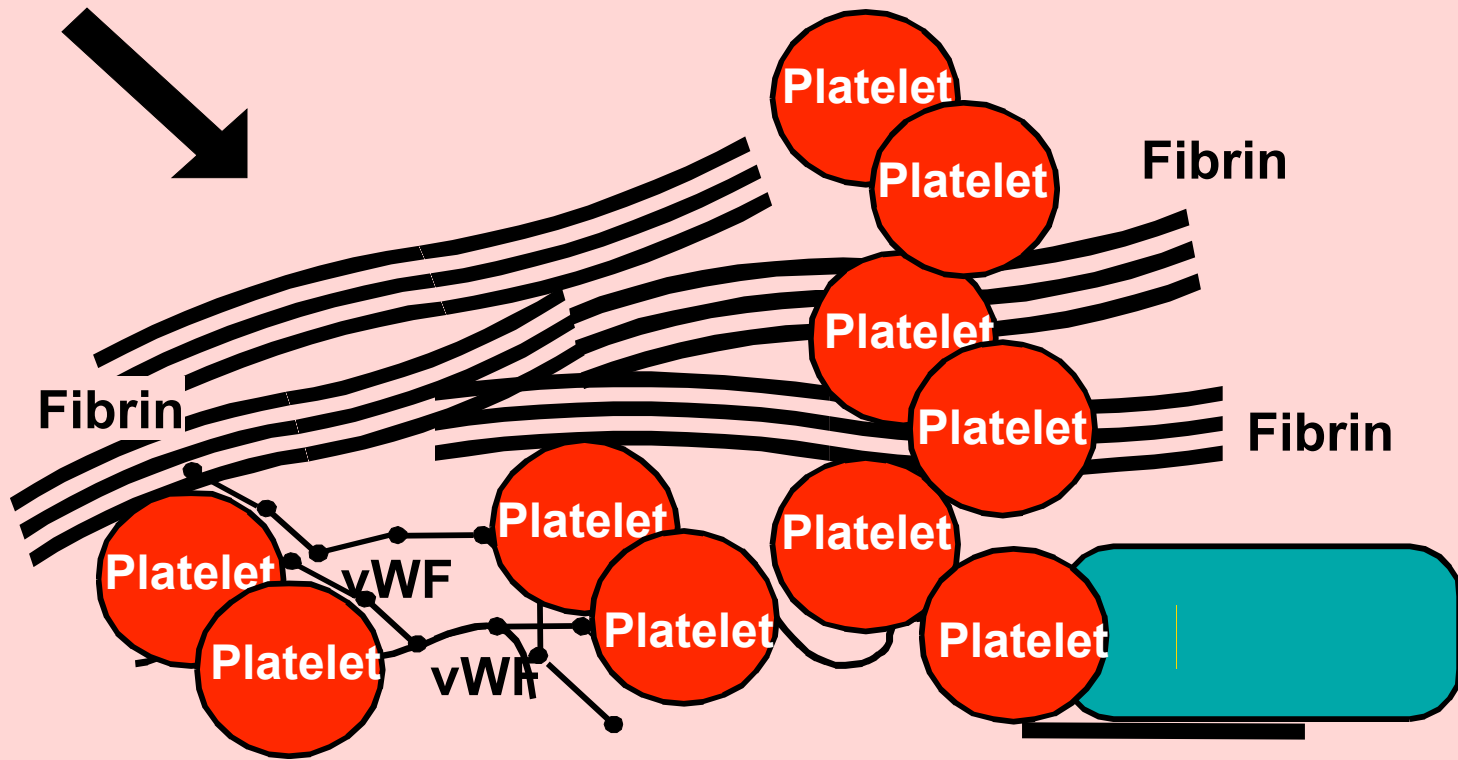
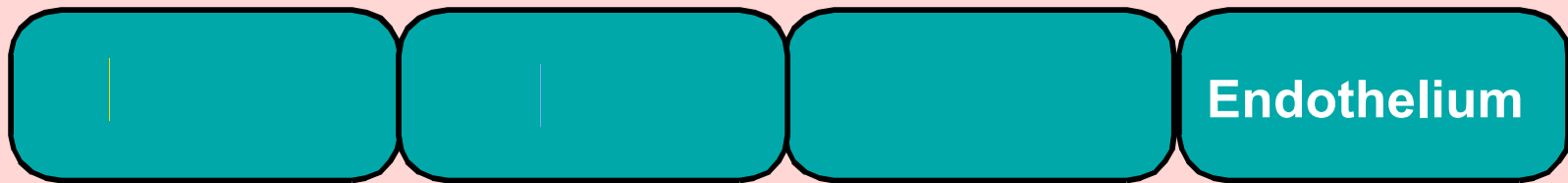


Method	No. of patients - CRRT
• Heparin	: 398
• Citrate	: 92
• Nafamostat mesilate	: 52
• LMWH	: 41
• Others	: 18
(hirudin 9, prostacyclin 7, danaparoid 2)	
• No anticoagulation	: 288

➤ 54 hospitals, 23 countries (Sept 2000 – Dec. 2001)



Fibrin Thrombus





International Normalised Ratio (INR)

- Prothrombin time is used for the detection of coagulation factor deficiencies due to Vit K deficiency and liver disease (II, VII, IX & X)
- Prothrombin time (PT) depends on II, VII and X.
- The result for the prothrombin time is expressed as a ratio (clotting time for patient plasma divided by the time for control plasma)

Activated Partial Thromboplastin Time (APTT)



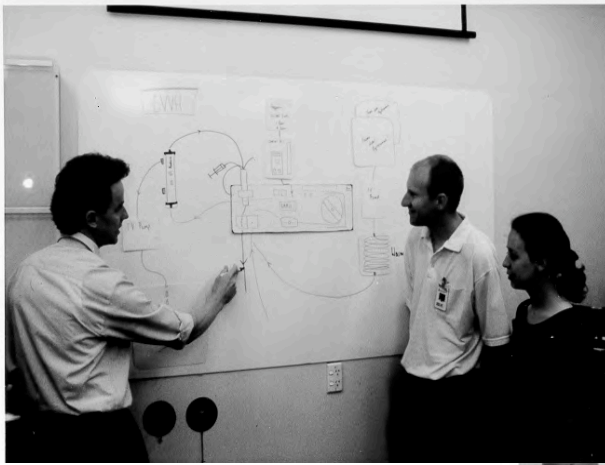
- deficiency in factors VIII, IX, XI, XII
- Heparin interferes with with the coagulation cascade at this point so APTT is useful in monitoring the effectiveness of the infusion



CRRT programs : Core curriculum Summary.

- Curriculum for CRRT needs to be defined
- Need to introduce into nursing schools
- Topics in sequence
- Many methods for providing 'core content'
- Background and 'theory' vital for practical

Teaching in sequenceAbstract to concrete...theory to practice



Theory



Simulation



Supervised experience

1 Day CRRT update and basics

ICU staff Study day – CRRT
ICU lecture theatre, ICU level 2
Thursday December 16th 2010



0830 - 0930

Renal physiology and ARF in critical illness

**0930 - 1030
1030 - 1100
1100 - 1200**

**RRT : therapy modes and application
T break
RRT : Anticoagulation**

**1200 - 1300
Ian Baldwin
1300 - 1400**

**RRT : Fluids and fluid balance

Lunch break**

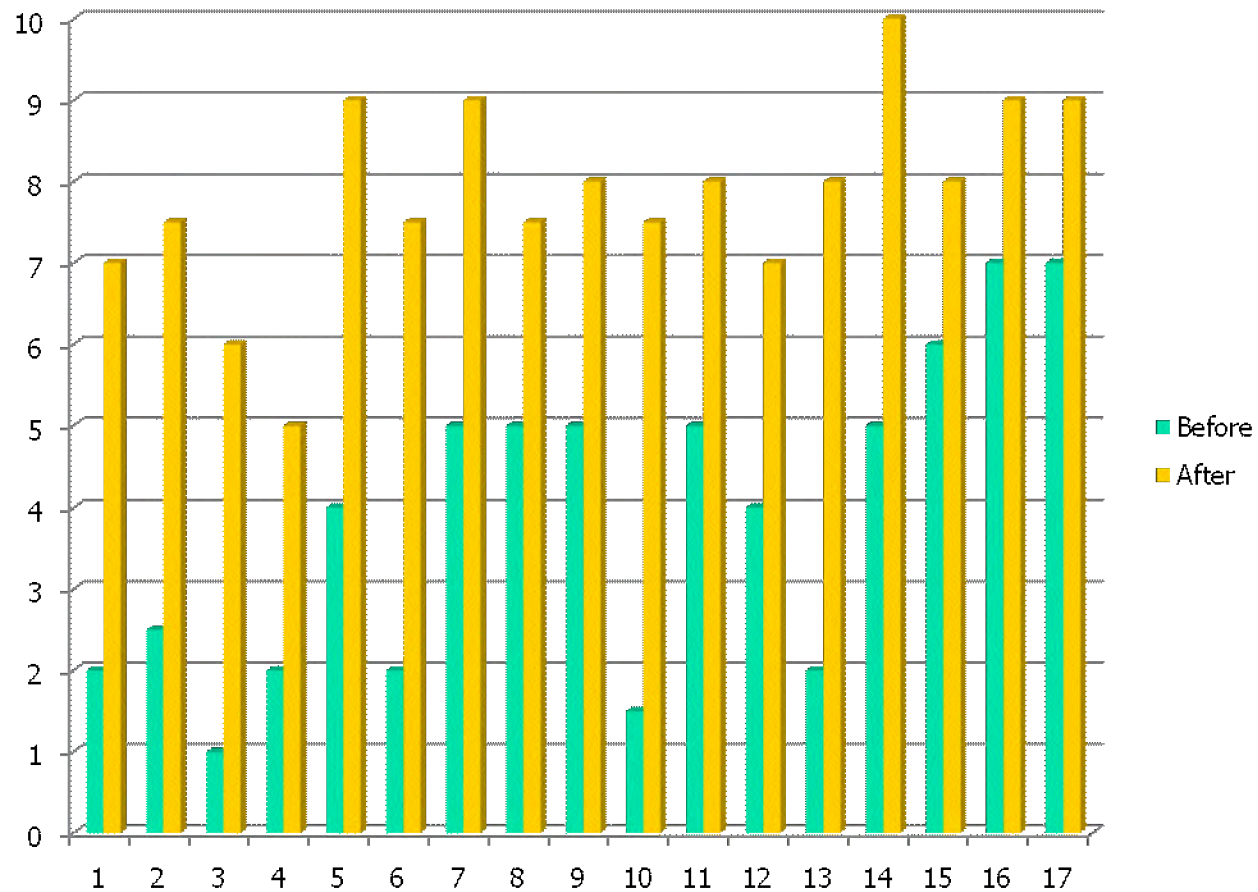
1400 - 1500

**Machine review & Priming Infomed (group 1)
Machine review & Priming Prismaflex (group 2)**

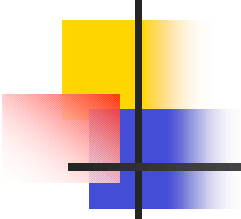
**1500 – 1515
1515– 1600**

**T Break
Panel : 'Facts' and 'Fiction' using CRRT
Your q's , our answers.....for CRRT**

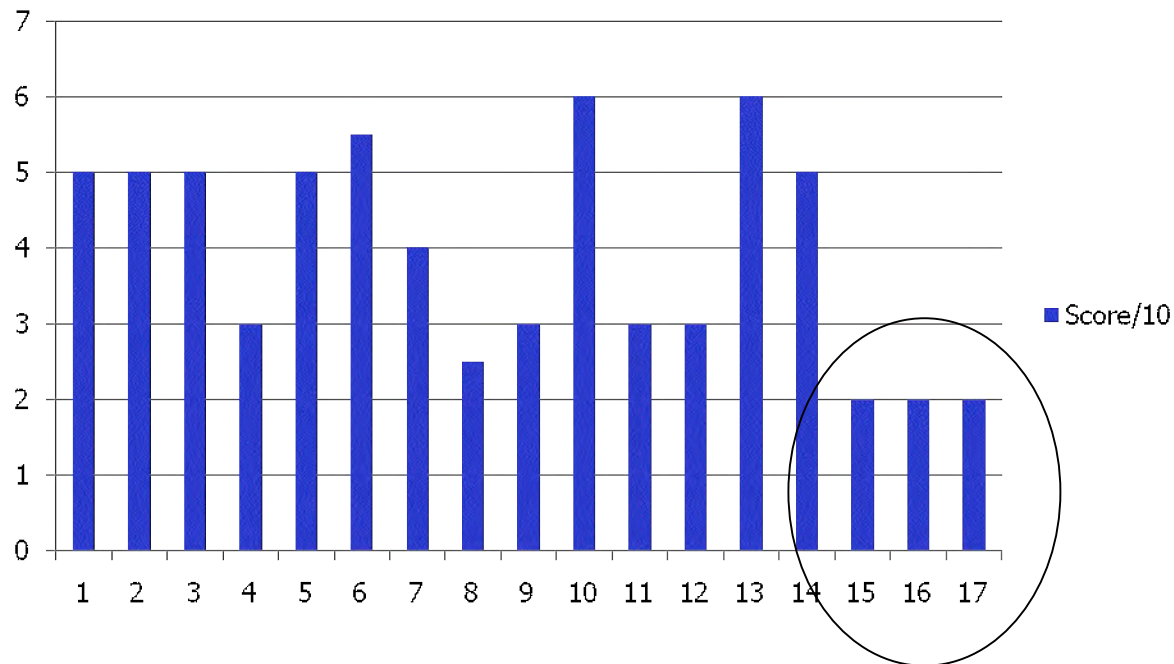
Self scoring for knowledge improvement after 1 day lecture and practical for CRRT : 17 nurses (December 2010)



Difference in knowledge (improvement) after 1 day lecture and practical for CRRT : 17 nurses



Knowledge improvement



(December 2010)

Human – machine interface

