YONSEI UNIVERSITY

2023년 비뇨의학과 신입 전공의 입문 교육

수액요법 및 일반적인 전신증상 치료법

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0. Background of fluid therapy

■ History of fluid therapy

Sir William Brooke O'Shaughnessy

- 1831년 Shaughnessy는 Edinburgh Medical School을 막 졸업한 22세에, 정맥 내 수액 (intravenous saline)
을 개(dog)에게 주입하였을 때, 해로운 작용이 일어나지 않는 것을 확인하였다.
- 그는 이 방법이 혈액의 자연적인 비중(specific gravity)을 회복하고 염수에서 부족한 물질들을 얻게 한다고 보고하였다.

0. Background of fluid therapy

Body fluid composition

	% of Body Weight	% of Total Body Water
Total Body Water	60	100
ICF	40	67
ECF	20	33
Intravascular	5	8
Interstitial	15	25

IV solution & IV orders

Each Fluids has its own special uses and Indications !!

Solution	Glu (g/L)	Osm (mOsm/kg)	Na (mEq/L)	Cl (mEq/L)	Indications	Cautions
5DW	50	252	0	0	To give free water To give medications No ECFV overload	Impair DM control Hyponatremia
1/2NS	0	154	77	77	To give both free water and Na Tx of hypertonic ECFV depleted state	Serious Hyponatremia in hypotonic plasma
NS*	0	308	154	154	ECFV replacement Perioperative fluid	ECFV overload in in CHF, RF
Ringer's Lactate*†	0	272	130	109	ECFV replacement Perioperative fluid	ECFV overload in in CHF, RF
3%NaCl	0	1026	513	513	Tx of severe HypoNa	Osm demyelination ECFV overload iatrogenic HyperNa

*: Also available with 5% dextrose
†: Also contain K 4 mEq/L, Ca 3 mEq/L, Lactate 28 mEq/L

Body fluid compartments

	ECF	ICF
Na	135-145 (mEq/L)	10-20 (mEq/L)
K	3.5-5.0(mEq/L)	130-140 (mEq/L)
Cl	95-105 (mEq/L)	20-30 (mEq/L)
HCO3	22-26 (mEq/L)	10-20 (mg/dl)
Glucose	90-120 (mg/dl)	
Ca	8.5-10 (mg/dl)	
Mg	1.4-2.1 (mEq/L)	
Urea*	10-20 (mg/dl)	

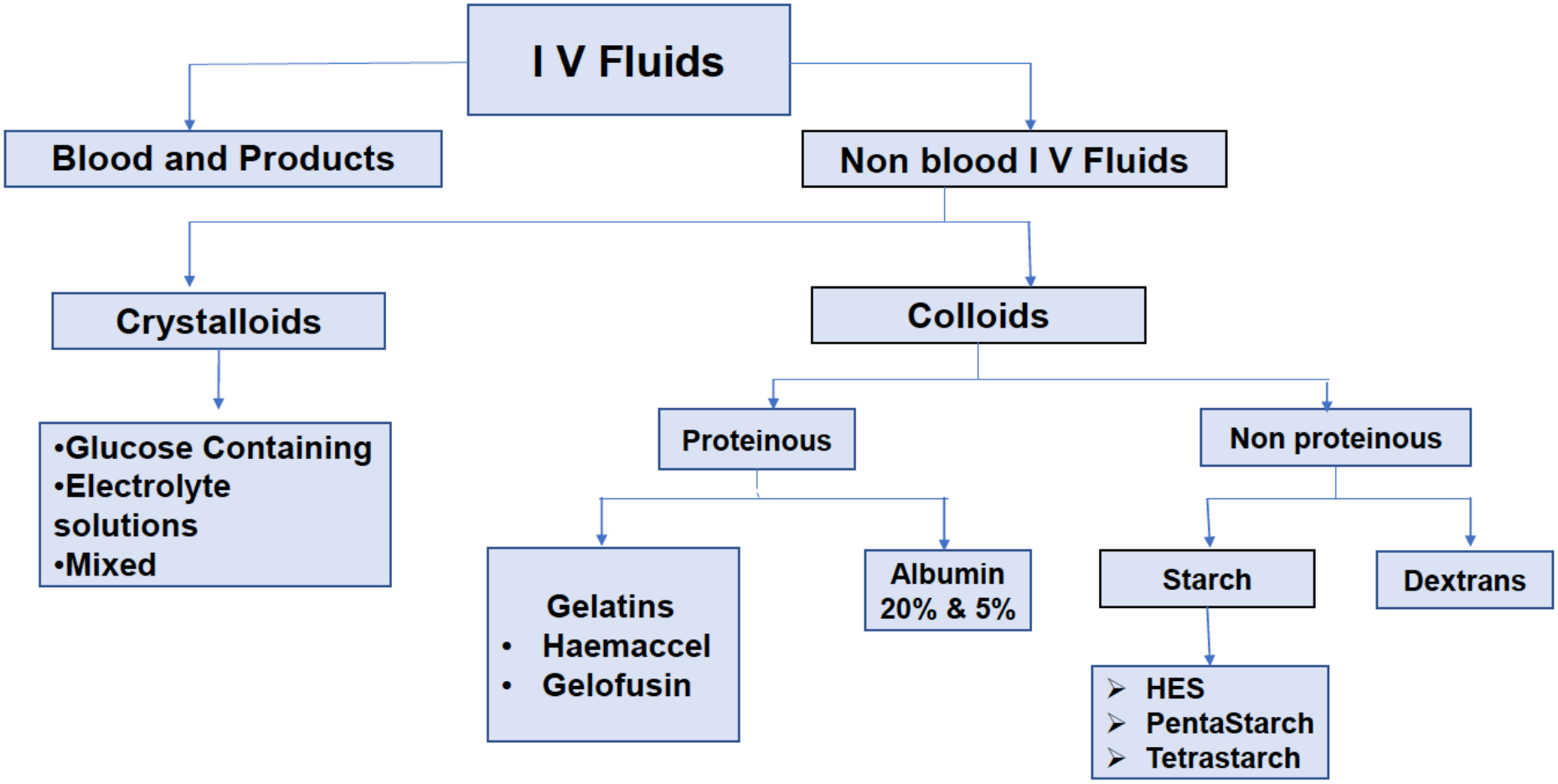
*Urea passes freely between ICF and ECF, not effective osmole

Maintenance fluid therapy

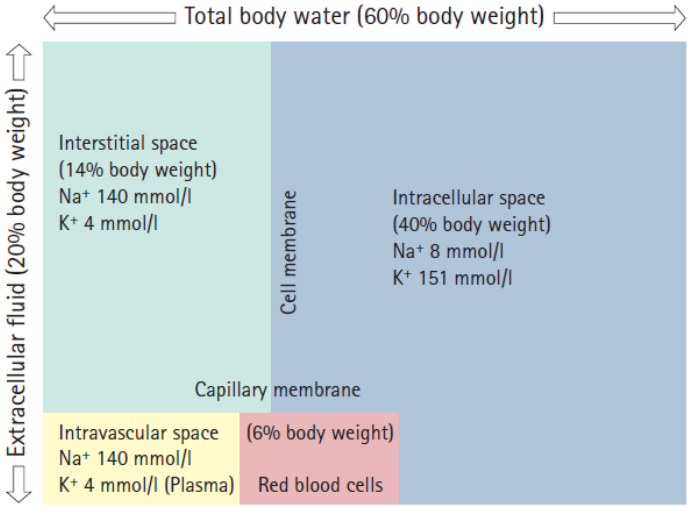
Fluid maintenance	
Body weight(kg)	ml/kg/d
< 10kg	100ml/kg
10 - 20kg	1000ml + 50ml/kg
> 20kg	1500ml + 20ml/kg

Electrolyte	Maintenance
Na+	2~4mEq/kg/day
K+	1~2mEq/kg/day
Cl-	2~4mEq/kg/day

0. Background of fluid therapy



0. Background of fluid therapy



Body fluid composition

	% of Body Weight	% of Total Body Water
Total Body Water	60	100
ICF	40	67
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Intravascular	5	8
Interstitial	15	25

1. Crystalloid (ex. 0.9% Normal saline 1L) : only ECF
-> intravascular space : 250cc(**1/4**)

2. Free water (ex. 5% DW 1L) : in TBW
-> intravascular space : 83cc(**1/12**)

3. Colloid (ex. Starch) : Intravascular space >> ECF
- 6% Starch (volulyte 500ml) -> 333cc(**2/3**)
- 5% Albumin (250ml) -> 166cc(2/3)
- 25% albumin (100ml) -> 400cc(**x4**)
  -> edema감소 (interstitial fluid to intravascular space)

Cf) pRBC transfusion시 혈장 성분이 없어 osmotic pr 자체는 적어,
intravascular -> interstitial or intracellular로 들어간다.

0. Background of fluid therapy

■ The aim of IV fluid administration

1. Avoid dehydration

2. Maintain an effective circulating volume

3. Prevent inadequate tissue perfusion during a period when the patient is unable to achieve these goals through normal oral fluid intake

4. Intravenous fluid have a range of physiologic effects and should be considered to be drugs with indications, dose ranges, cautions and side effects.

0. Background of fluid therapy

■ Approach to fluid prescribing strategy

Title	Details
Normal physiology	Understand key physiology of fluid balance
Initial assessment	Assess the patient's likely fluid and electrolyteneeds
Resuscitation	IV fluids may need to be given urgently to restore circulation to vitalorgans
Routine maintenance	IV fluids are needed for patients who simply cannot meet their normal fluid or electrolyte needs by oral or enteral routes
Replacement	IV fluids to treat losses from intravascular and or other fluid compartments, and correct e xisting water and/or electrolyte deficits or ongoing external losses
Redistribution	some hospital patients have marked internal fluid distribution changes or abnormal flu id handling
Reassessment	All patients continuing to receive IV fluids need regularmonitoring

1.Fluid status assessment and monitoring

■ The aim of IV fluid administration

History taking

Previous limited intake, thirst, abnormal losses, comorbidities, malnourished.

Clinical examination

BP, Pulse, Capillary refill, jugular venous pressure

Pulmonary edema, effusion, postural hypotension

Monitoring

NEWS, Urine output, I/O charts, weight

Lab

CBC, BUN/Cr, Electrolytes

1.Fluid status assessment and monitoring

1) Urine output, color

Oliguria : U/O < 0.24ml/kg/hr / Straw or concentrated

POD#2, 70kg, 150cc/duty 나왔습니다.

2) PEx

Thirsty, Skin turgor, ansarca(부종) 유무, weight 변화

목이 많이 마르세요?

3) Mornotoring

HR, BP 변화 추이 (baseline과 비교), I/O, intra-op I/O, Diet 유무, Fluid 종류

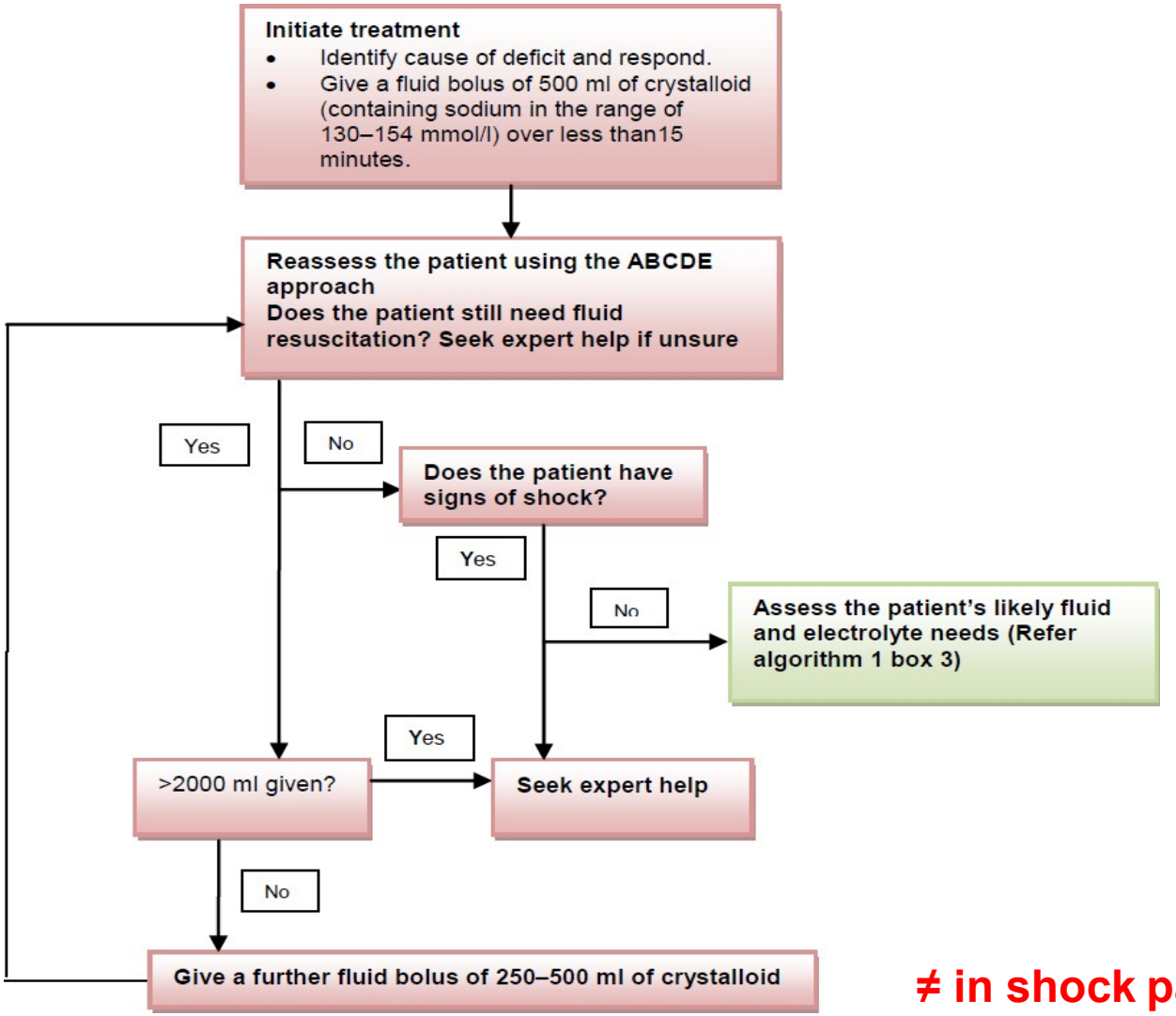
Tachycardia가 있진 않은지, kg당 Fluid는 맞게 들어가는지

4) Lab

BUN/Cr ratio : 20이상(Dry), 10이하(Wet), U/A, electrolyte, albumin

BUN, Cr이 elevation이 있는지, Urine S.G가 1.030이 넘진 않는지. Fluid에 electrolyte는 잘 들어가는지

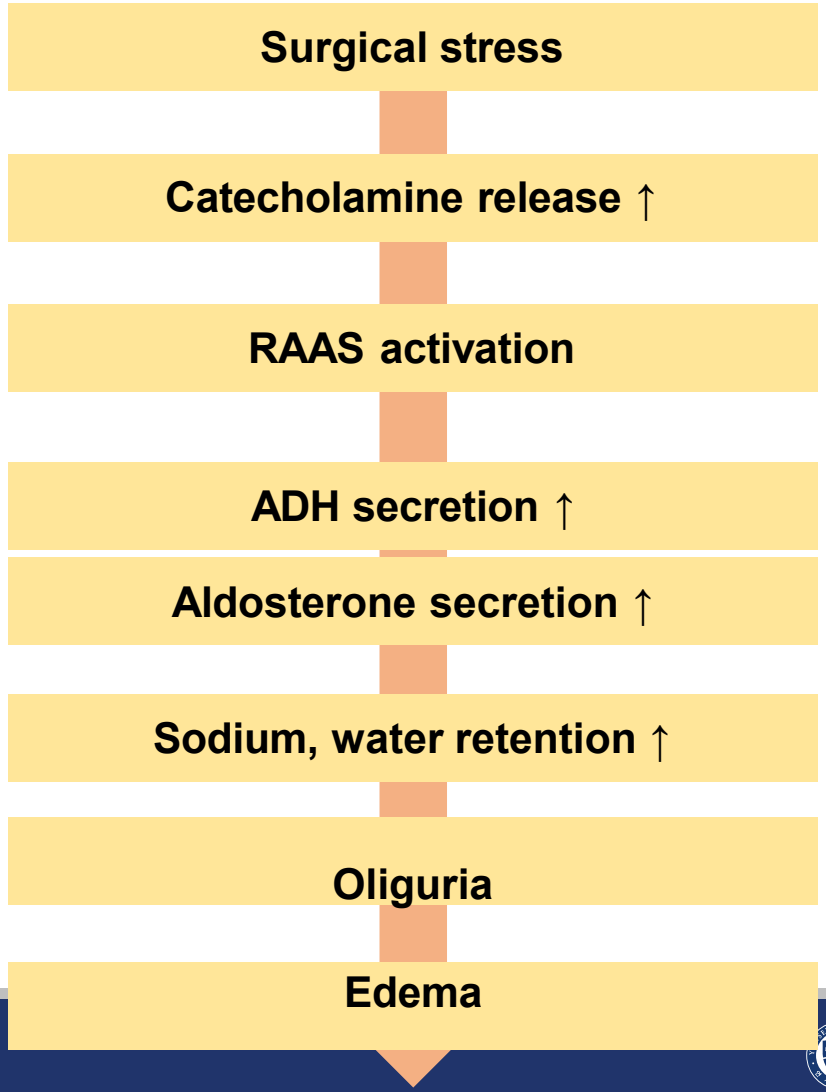
2. Resuscitation



≠ in shock patients

2. Resuscitation

■ Furosemide (Lasix는 신중하게)



수술 후 oliguia의 원인 :

Insufficient IV volume

-> Decreased renal blood flow

-> decreased urine output

-> RAS system activation

-> water preservation

- Post inflammatory change에 의한 oliguric phase의 가능성

If IV Lasix -> unable to hold water and increasing urine output

-> IV volume deficit -> dehydration -> AKI -> Mortality ?

Post op 환자에서 lasix를 고려할 때는, 환자의 전신상태등을 충분히 고려한 뒤에 사용하여야 한다.

2. Resuscitation

- SBP <100 mmHg
- PR >90/min
- Capillary refill time >2 sec or cold peripheries.
- RR >20/min
- National Early Warning Score (NEWS) ≥5
- Positive passive leg raising test

Use crystalloids contain sodium in the range 130–154 mmol/l, with a bolus of 500 ml over less than 15 minutes.
Do not use tetrastarch.
If severe sepsis, consider Albumin solution.

3. Routine maintenance

- 25–30 ml/kg/day of water.
- 1 mmol/kg/day of potassium, sodium and chloride (NICE guideline)

  - Na 요구량 = Sabiston (2-3mmol/kg/day), 외과학 (1-2mmol/kg/day)
- 50–100 g/day of glucose to limit starvation ketosis.
- For obese patients, Adjust IV fluid to their ideal body weight.
- Consider less fluid volume for patients with older, frail, renal impairment, cardiac failure, malnourished, at risk of refeeding syndrome.

3. Routine maintenance

NICE National Institute for Health and Care Excellence

NICE

Intravenous fluid therapy in adults in hospital

Contents of Maintenance Solution (commonly used, 60kg adult)

Contents	NICE	Sabiston 20th	외 과 학
Water	1500-1800cc	2400cc	2300cc
Dextrose	50-100g	100g	undescribed
Sodium	1mEq/kg	2-3mEq/kg	1-2mEq/kg
Potassium	1mEq/kg	0.5-1mEq/kg	0.5-1mEq/kg
Maintenance rate	**Maintenance rate(cc/hr)** 25-30cc/kg	**Maintenance (cc/hr)** 4 cc/kg for first 10kg 2cc/ kg for next 10kg 1cc/kg for every kg over 20kg	**Maintenance (cc/day)** 1 00cc/kg for first 10kg 50 cc/kg for next 10kg 20cc /kg for every kg over 20k g

**Consider prescribing less fluid (20–25cc/kg/day) for older, CKD, HF patients

3. Routine maintenance

70kg patient

Diet : NPO

Maintenance : 30x70 = 2100cc

Na = 70~140mEq

K = 70mEq

How to make the fluid?

3. Routine maintenance

Composition of commonly used crystalloids

Content	Plasma	Sodium chloride 0.9%*	Sodium chloride 0.18%/ 4% glucose[a]	0.45% NaCl/ 4% glucose[a]	5% glucose[a]	Hartmann's	Lactated Ringer's (USP)	Ringer's acetate	Alternative balanced solutions for resuscitation**	Alternative balanced solutions for maintenance**
Na^+ (mmol/l)	135–145	154	31	77	0	131	130	130	140	40
Cl^- (mmol/l)	95–105	154	31	77	0	111	109	112	98	40
$[Na^+]:[Cl^-]$ ratio	1.28–1.45:1	1:1	1:1	1:1	-	1.18:1	1.19:1	1.16:1	1.43:1	1:1
K^+ (mmol/l)	3.5–5.3	*	*	*	*	5	4	5	5	13
HCO_3^-/ Bicarbonate	24–32	0	0	0	0	29 (lactate)	28 (lactate)	27 (acetate)	27 (acetate) 23 (gluconate)	16 (acetate)
Ca^{2+} (mmol/l)	2.2–2.6	0	0	0	0	2	1.4	1	0	0
Mg^{2+} (mmol/l)	0.8–1.2	0		0		0	0	1	1.5	1.5
Glucose (mmol/ l)	3.5–5.5	0	222 (40 g)	222 (40 g)	278 (50 g)	0	0	0	0	222 (40 g)
pH	7.35–7.45	4.5–7.0	4.5		3.5–5.5	5.0–7.0	6–7.5	6–8	4.0–8.0	4.5–7.0
Osmolarity (mOsm/l)	275–295	308	284		278	278	273	276	295	389

* These solutions are available with differing quantities of potassium already added, and the potassium-containing versions are usually more appropriate for meeting maintenance needs.
** Alternative balanced solutions are available commercially under different brand names and composition may vary by preparation.
[a] The term dextrose refers to the dextro-rotatory isomer of glucose that can be metabolised and is the only form used in IV fluids. However IV fluid bags are often labelled as glucose so only this term should be used. Traditionally hospitals bought a small range of fluids combining saline (0.18-0.9%) with glucose but several recent NICE/NPSA documents have recommended specific combinations, which are now purchased to enable guidelines to be followed. Glucose–saline combinations now come in 5 different concentrations, and the addition of variable potassium content expands the pre-mixed range to 13 different products. Prescribers must therefore specify the concentration of each component; the term dextrose-saline (or abbreviation D/S) is meaningless without these details. What is specified also impacts significantly on the cost of the product.
Note: Weight-based potassium prescriptions should be rounded to the nearest common fluids available (for example, a 67 kg person should have fluids containing 20 mmol and 40 mmol of potassium in a 24-hour period). Potassium should not be added to intravenous fluid bags as this is dangerous.

Source: This table was drafted based on the consensus decision of the members of the Guideline Development Group.

'Intravenous fluid therapy in adults in hospital', NICE clinical guideline 174 (December 2013. Last update December 2016)

3. Routine maintenance

Examples of maintenance fluid regimens (2-2.5L/day) suitable for a 70 kg person

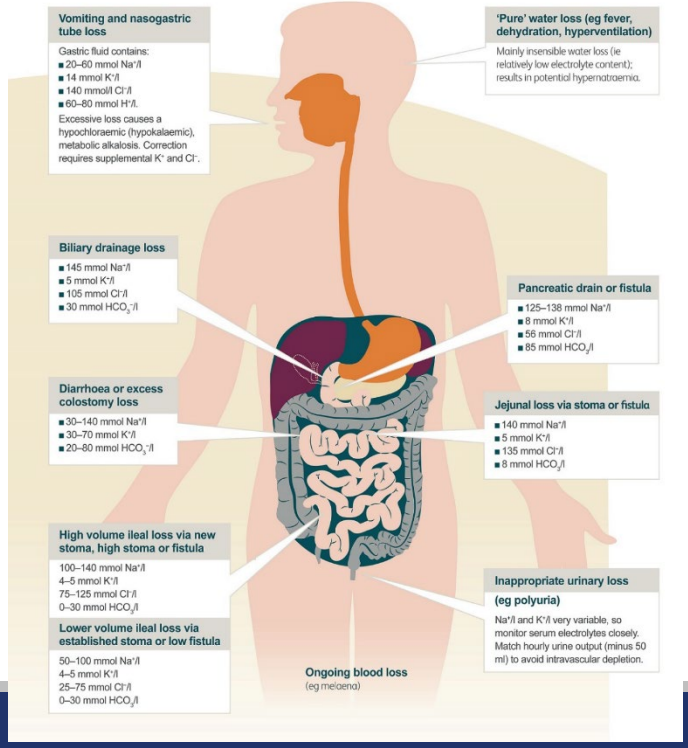
	70kg person requirement	0.45% saline (1-1.5L) + 5% dextrose (1L)	0.9% saline + K 40mEq (Nak fluid) (0.5L) + 5% dextrose (1.5-2L)	Plasmalyte maintenance (2-2.5L)	Ringer's lactate (1L) + 5% dextrose (1-1.5L)	Hartmann's (1L) + 5% dextrose (1-1.5L)
Water (L)	2.1	2-2.5	2-2.5	2-2.5	2-2.5	2-2.5
Na^+ (mmoL)	70-140	77-116	77	80-100	130	131
Cl^- (mmoL)	70-140	77-116	77	80-100	109	111
K^+ (mmoL)	70	0	40	26-33	4	5
Dextrose (g)	100	50	75-100	100-125	50-75	50-75
$Ca2^+$ (mmoL)					3	4
Lactate (mmoL)					28	29
Acetate (mmoL)				32-40		
Malate (mmoL)						
$Mg\ 2^+$ (mmoL)				3-4		

일반적으로 사용하는 fluid는 Potassium replacement 량이 부족하고, Na은 과다하게 들어가는 경우가 많다. 0.9% N/S + K 40mEq 제제나 1L mix 제제를 사용과 동시에 , 제제 500ml + 5DW를 했을 때 그나마 이상적인 requirement 값이 나온다.

이는 K replacemen의 결핍에 의한 것이나, 추가적으로 electrolyte 및 Urine outpu을 f/u하면서 fluid를 증감조절 할 필요가 있다.

4. Replacement and redistribution

- Adjust the IV prescription to account for existing fluid and/or electrolyte deficits or excesses, ongoing losses, abnormal distribution.
  - Gross edema, Severe sepsis, hypo/hypernatremia, renal/liver/cardiac impairment, postop fluid retention and redistribution, malnourished, refeeding issues.



Q1. L-tube 1L drainage 하는 70kg, NPO중인 patient?

Q2. Diarrhea 1L 씩 하는 70kg, NPO patient

4. Replacement and redistribution

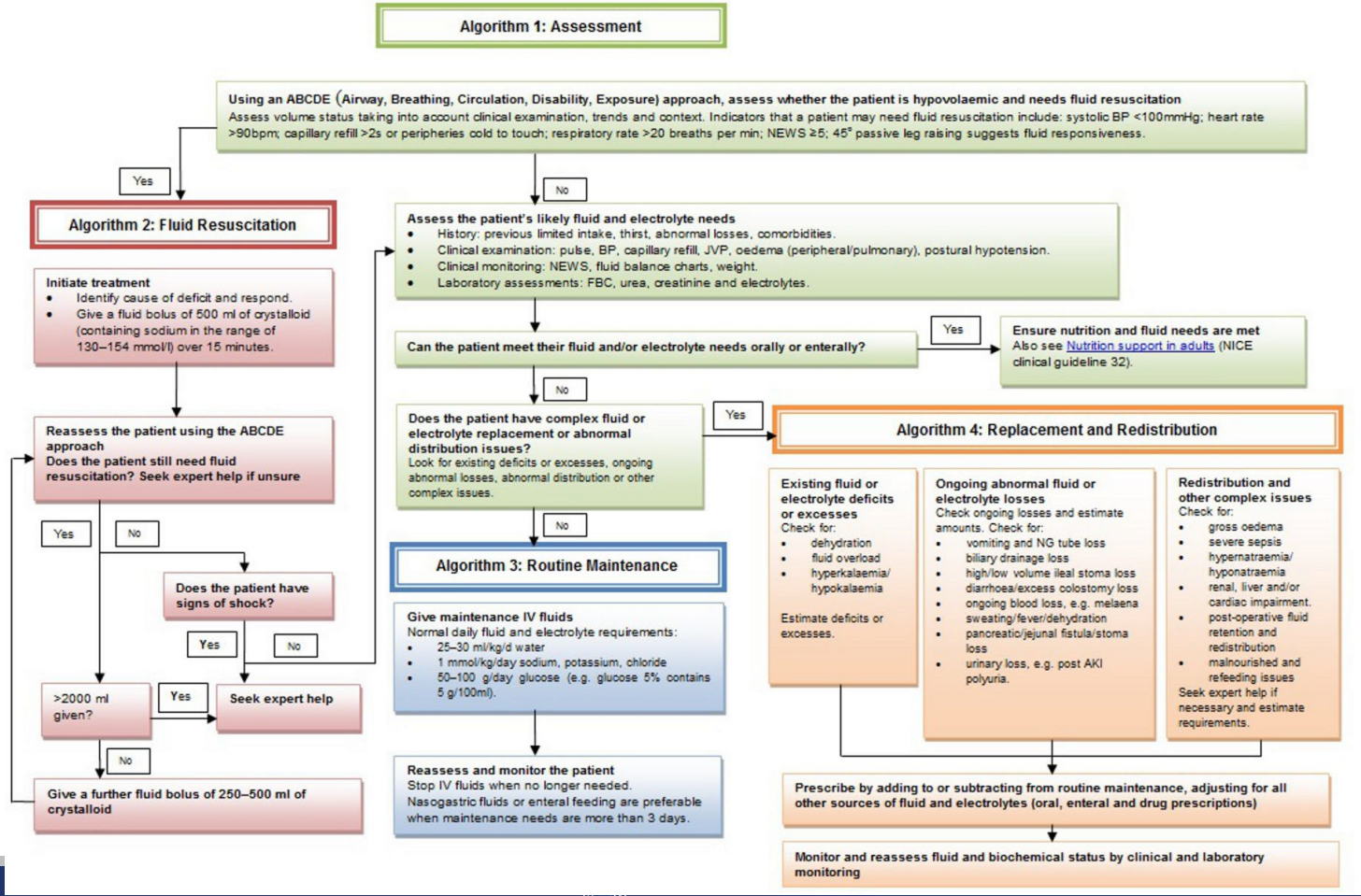
Vomiting obstruction	70kg person requirement	Loss 되는 양	합계	1)0.9% saline + K 40mEq (Nak fluid) (0.5L)*2 + 5% dextrose (2L)	2) K40NS1000 1L(K 40meq, Na154meq,cl194meq)+ 5%d extrose 2L +side(K20NS100 1000ml*2)
Water (L)	2.1	1	3.1	3	3.2
Na^+ (mmol)	70-140	40	110-180	154	184.8
Cl^- (mmol)	70-140	140	210-280	154	264.8
K^+ (mmol)	70	14	84	80	80
Dextrose (g)	100		100	100	100
Hco3-(mmol)		60-80	60-80		

Diarrhea	70kg person requirement	Loss 되는 양	합계	1)0.9% saline + K 40mEq (Nak fluid) (0.5L)*2 + 5% dextrose (2L) +side(K20NS100 1000ml)
Water (L)	2.1	1	3.1	3
Na^+ (mmol)	70-140	30-140	100-280	169
Cl^- (mmol)	70-140		70-140	189
K^+ (mmol)	70	30-70	100-140	100
Dextrose (g)	100		100	100
Hco3-(mmol)		20-80	20-80	

5. Reassessment

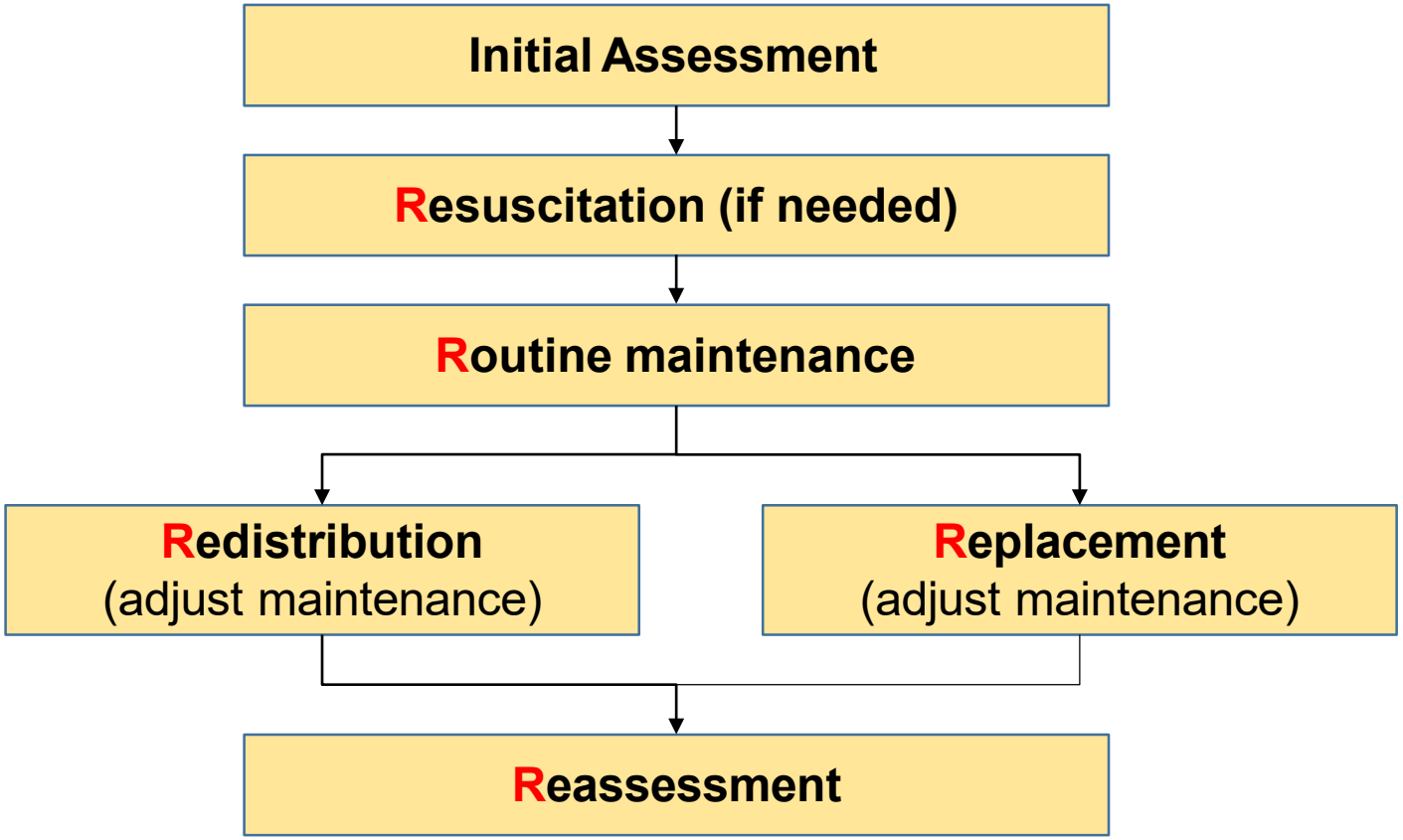
Careful monitoring is needed to minimize the risks of adverse events such as fluid overload, hypovolaemia, and electrolyte disturbances.

Do not prescribe fluids for more than 24 hours and assess fluid status at least daily, if not more often.



Summary

Prescribing IV fluid ; the 5 Rs



Summary

- Crytalloid solution은 ECF 대체 용액, 전해질 보충, 열량 공급의 기능을 가지고 있다.
- IV fluid는 다양한 physiologic effects가 있기 때문에 적응증, 용량, 주의 및 부작용이 있는 약물치료의 하나로 생각해야 한다.
- Isotonic saline (N/S)이 가장 기본이다.
- 출혈이 심하거나 hypovolemic shock의 치료에는 혈액 성분을 사용하였으나, 급성 출혈 시 WB의 사용 외에는 N/S이 효과적이다.
- 심한 hypovolemia의 교정에서는 Hartmann solution의 사용이 효과적이다.
- Plasma-lyte는 인체 혈장과 유사한 Na, Mg, K으로 조성된 solution으로 hemorrhagic shock과 같이 긴급수혈시에 함께 투여할 수 있다.
- The prescription of IV fluid **should be changed every day**, according to patient fluid status assessment
- **Less sodium.. less sodium.. less sodium!!**