YONSEI UNIVERSITY

2021년 비뇨의학과 신입 전공의 입문 교육

수액요법 및 일반적인 전신증상 치료법

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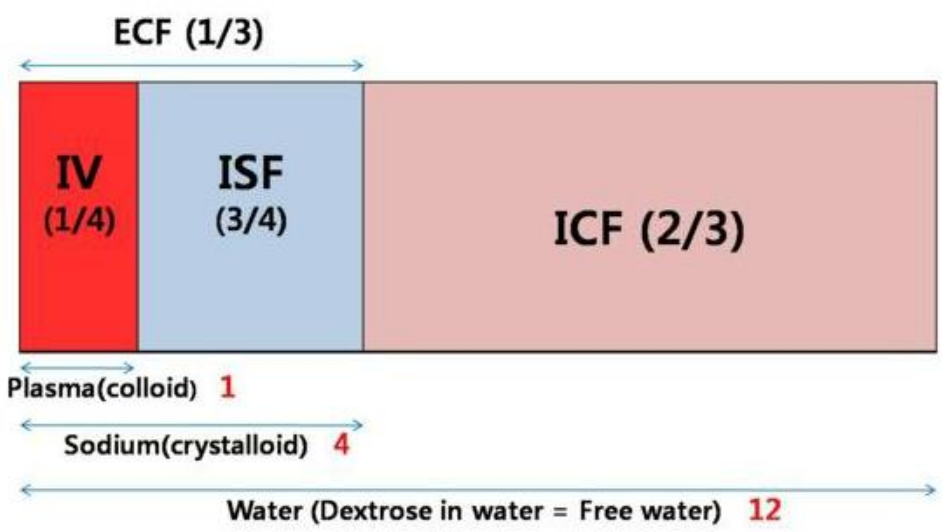
History of fluid therapy

- Sir William Brooke O'Shaughnessy
  - 1809-1889
  - 1831년 Shaughnessy는 Edinburgh Medical School을 막 졸업한 22세에 이 말들을 남겼다. 그는 정맥내수액(intravenous saline)을 개(dog)에게 주입하여 실험하였고 해로운 작용이 일어나지 않는 것을 확인하였다. 그는 이 방법이 혈액의 자연적인 비중(specific gravity)을 회복하고 염수에서 부족한 물질들을 얻게 한다고 보고하였다.

Background of fluid therapy

- 수액 공급의 필요량
  - 2,000-2,500 mL (성인)
    - Urine output 1,500mL + insensible loss 500-1000 mL
  - 체내 총 수분량 (total body water; TBW)
    - 남성 60% 여성 50% (체중 대비)
    - 세포내액 (ICF)과 세포외액 (ECF; interstitial fluid + plasma)

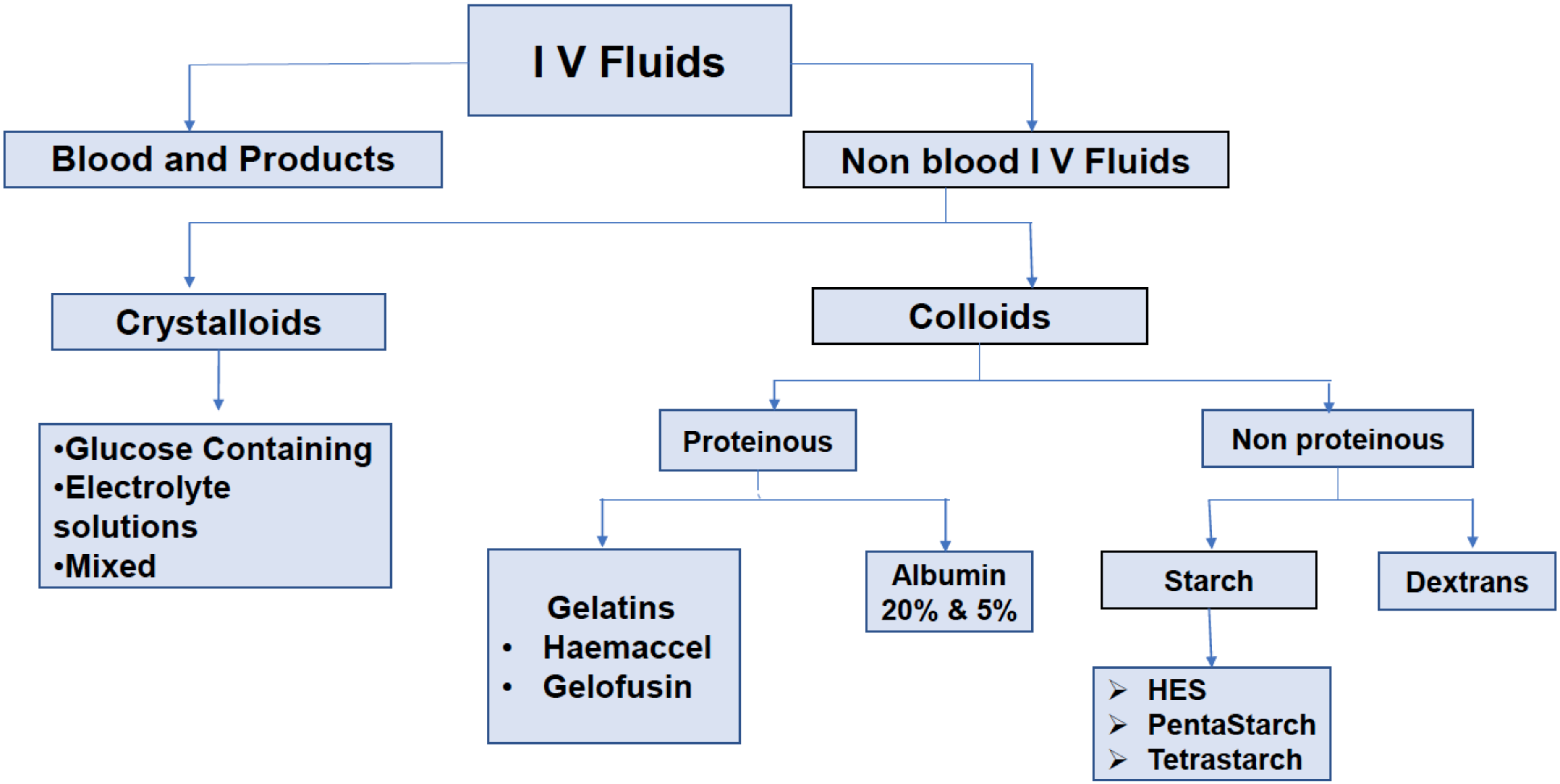


Classification of fluid therapy

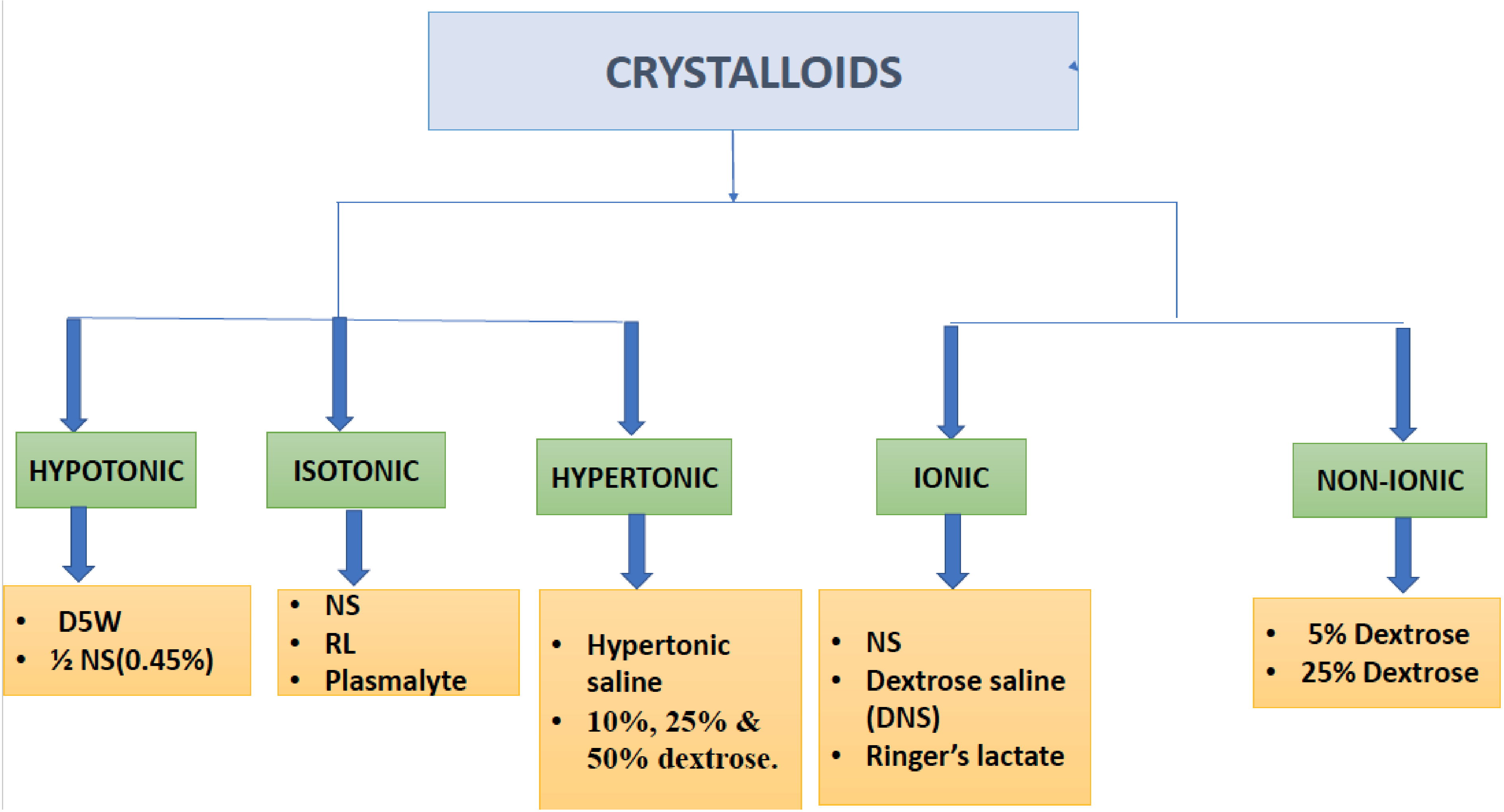
- Colloid
  - 혈액양 대체 용액
  - Plasma, albumin, blood products

- Crytalloid
  - ECF 대체 용액, 전해질 보충, 열량 공급
    - Hypotonic: Plasma보다 낮은 삼투압 → ICF 내로 이동
    - Isotonic: Plasma와 동일한 삼투압
    - Hypertonic: 세포외로 물을 이동 → 세포는 수축

Classification of fluid therapy



Crystalloids



Starling forces

- 확산(diffusion)은 capillary를 통한 수액이 이동에 가장 중요한 부분을 차지
  - Hydrostatic pressure
  - Osmotic pressure

- Capillary를 통한 수액의 이동의 두 힘의 산술적 합
  - 동맥혈 부분은 hydrostatic pr가 주가되어 interstitium으로 수액이 이동
  - 정맥혈 부분은 osmotic pr가 주가 되어 역의 방향으로 수액이 이동
  - 동맥 부분에서 이동한 수액의 10%는 lymphatics로 uptake

The aim of IV fluid administration

- Avoid dehydration
- Maintain an effective circulating volume
- Prevent inadequate tissue perfusion during a period when the patient is unable to achieve these goals through normal oral fluid intake
- Intravenous fluid have a range of physiologic effects and should be considered to be drugs with indications, dose ranges, cautions and side effects.

Normal saline

- One of the most commonly administered crystalloids

- Using in vitro red cell lysis experiments, Hamburger ascertained that 0.9% was the NaCl concentration that was isotonic with human plasma. It was not initially developed with the aim of in vivo administration, yet has entered widespread clinical use despite having a Na+ and Cl- concentration far in excess of that of plasma

- 0.9% saline also known as normal saline, physiological saline, isotonic saline – but none of these names are appropriate as chemically it is not normal because the concentration of a one-normal (1 N) NaCl solution is 58 grams per liter (the combined molecular weights of sodium and chloride), while 0.9% NaCl contains only 9 grams of NaCl per liter

Normal saline

- ***Volume effects of NS***
  - Infusion of one liter of 0.9% NaCl adds 275 mL to the plasma volume and 825 mL to the interstitial volume
  - One unexpected finding; i.e., the total increase in extracellular volume (1,100 mL) is slightly greater than the infused volume. This is the result of a fluid shift from the intracellular to extracellular fluid, which occurs because 0.9% NaCl is slightly hypertonic in relation to Extracellular fluid

- ***Acid-Base Effect***
  - Large-volume infusions of 0.9% NaCl produce a metabolic acidosis
  - The saline-induced metabolic acidosis is a hyperchloremic acidosis, and is caused by the high concentration of chloride in 0.9% saline relative to plasma (154 versus 103 mEq/L)

Indication for normal saline

- To maintain effective blood volume and blood pressure in emergencies
- Water and salt depletion - diarrhea, vomiting, excessive diuresis or excessive perspiration
- Hypovolemic shock- distributed in extracellular space expanding the intravascular volume.
- Ideal fluid to increase blood pressure.
- Preferred in case of brain injury, hypochloremic metabolic alkalosis , hyponatremia
- Initial fluid therapy in DKA
- In patients with hyperkalemia like renal failure
- Hypercalcemia
- Fluid challenge in prerenal ARF
- Irrigation for washing of body fluids
- Vehicle for certain drugs

Ringer's lactate

- In 1880, Sydney Ringer (1835-1910), a British physician studied the contraction of isolated frog heart

- He introduced a solution that contained calcium and potassium in sodium chloride solution to promote cardiac contraction and cell viability. This is known as Ringer's injection

- In early 1930, an American pediatrician named Alexis Frank Hartmann (1898-1964) added sodium lactate to Ringer's solution as a buffer to metabolic acidosis

- This is known as Hartmann's solution or Ringer's lactate

Hartmann solution

- ***Advantage***
  - Lack of significant effect on acid base balance

- ***Disadvantage***
  - Presence of ionized calcium in ringer's lactate can binds to citrated anticoagulant in stored blood and promote formation of clots. (clot formation does not occur if the volume of Ringer's solution does not exceed 50% of the volume of packed RBCs)
  - In critically ill patients with impaired lactate clearance due to circulatory shock or hepatic insufficiency, Ringer's lactate infusion can increase serum lactate levels

Hartmann solution

- Ringer's lactate is the most physiological fluid as the electrolyte content is similar to that of plasma. Larger volumes can be infused without the risk of electrolyte imbalance

- Due to high Na (130mEq/L) content, Ringer’s lactate rapidly expands intravascular volume effective in treatment of hypovolemia

- Sodium lactate in Ringer’s lactate is metabolized to bicarbonate in the liver - useful in correction of metabolic acidosis

Indication of Hartmann solution

- Correction in severe hypovolemia
- Replacing fluid in post operative patients, burns , fractures
- Diarrhea induced hypokalemic metabolic acidosis and hypovolemia
- Fluid of choice in diarrhea induced dehydration in pediatric patients
- In DKA, provides glucose free water, correct metabolic acidosis and supplies potassium
- Maintaining fluid during surgery

Plasm-Lyte 148

- NS and Hartmann solution are commonly available crystalloid solutions worldwide.
  - However, their electrolyte composition is significantly different from that of plasma.

	Na^+	K^+	Mg^{++}	Cl^-	CH_3COO^- (Acetate)	$C_6H_{11}O_7^-$ (Gluconate)
mEq/L	140	5.0	3.0	98	27	23

- For fluid replacement (e.g. after burns, head injury, fracture, infection, and peritoneal irritation),
- As intraoperative fluid replacement,
- In hemorrhagic shock and clinical conditions requiring rapid blood transfusions (compatibility with blood),
- In mild to moderate metabolic acidosis, also in case of lactate metabolism impairment.

Table 1. Plasma and Commonly Used Intravenous Crystalloid Solutions

Fluid	mEq/L						pH	Osmolality (mOsm/L)
	Na^+	Cl^-	K^+	Ca^{++}	Mg^{++}	Buffers		
Plasma	140	103	4	5	2	Bicarbonate (25)	7.4	290
0.9% NaCl	154	154	-	-	-	-	5.7	308
Hartmann solution	130	109	4	3	-	Lactate (28)	6.4	273
Plasma-Lyte Plasma solution-A	140	98	5	-	3	Acetate (27) Gluconate (23)	7.4	295

	다음 환자에는 투여하지 말 것.	다음 환자에는 신중히 투여할 것.
Plasma solution	1) 수분과다상태 환자	1) 울혈성심부전, 신부전 및 나트륨 저류로 인한 부종 환자
	2) 고나트륨혈증 환자	2) 고칼륨혈증, 칼륨 저류 환자
		3) 대사성 또는 호흡성 알칼리증 환자
		4) 초산염이나 글루콘산염이 증가되어 있거나 간부전과 같이 이러한 이온의 이용이 손상된 환자
		5) 고장성 탈수증 환자
		6) 저나트륨혈증(120mmol/L 미만) 환자
Hartman solution	1) 젖산혈증 환자	1) 신질환에서 기인한 신부전 환자
	2) 수분과다상태 환자	2) 심부전 환자
	3) 고나트륨혈증 환자	3) 고장성 탈수증 환자
	4) 신생아(≤28일)에서는 다른 칼슘 함유 제품과 마찬가지로 별도의 주입선을 사용하는 경우라도, 세프트리악손과 이 약을 병용하여 사용하지 말 것 (신생아의 혈액에 치명적인 세프트리악손 칼슘 염의 침전 위험)	4) 폐쇄성 요로질환에 의한 요량감소가 있는 환자
		5) 중증 간장애 환자
		6) 저나트륨혈증(120 mmol/L 미만) 환자
Normal saline	1) 고나트륨혈증 환자	1) 심장·순환기계기능장애 환자
	2) 수분과다상태 환자	2) 신장애 환자
	3) 부종과 복수를 동반한 간경화 환자	3) 저단백혈증 환자
		4) 저나트륨혈증(120mmol/L 미만) 환자
		5) 저칼륨혈증 환자
		6) 고염소혈증 환자
		7) 말초 또는 폐부종 환자
		8) 자간전증 환자
		9) 알도스테론증 또는 나트륨 배설과 관련된 상태나 치료(코르티코스테로이드 또는 코르티코트로핀)중인 환자

NICE National Institute for Health and Care Excellence

NICE guideline

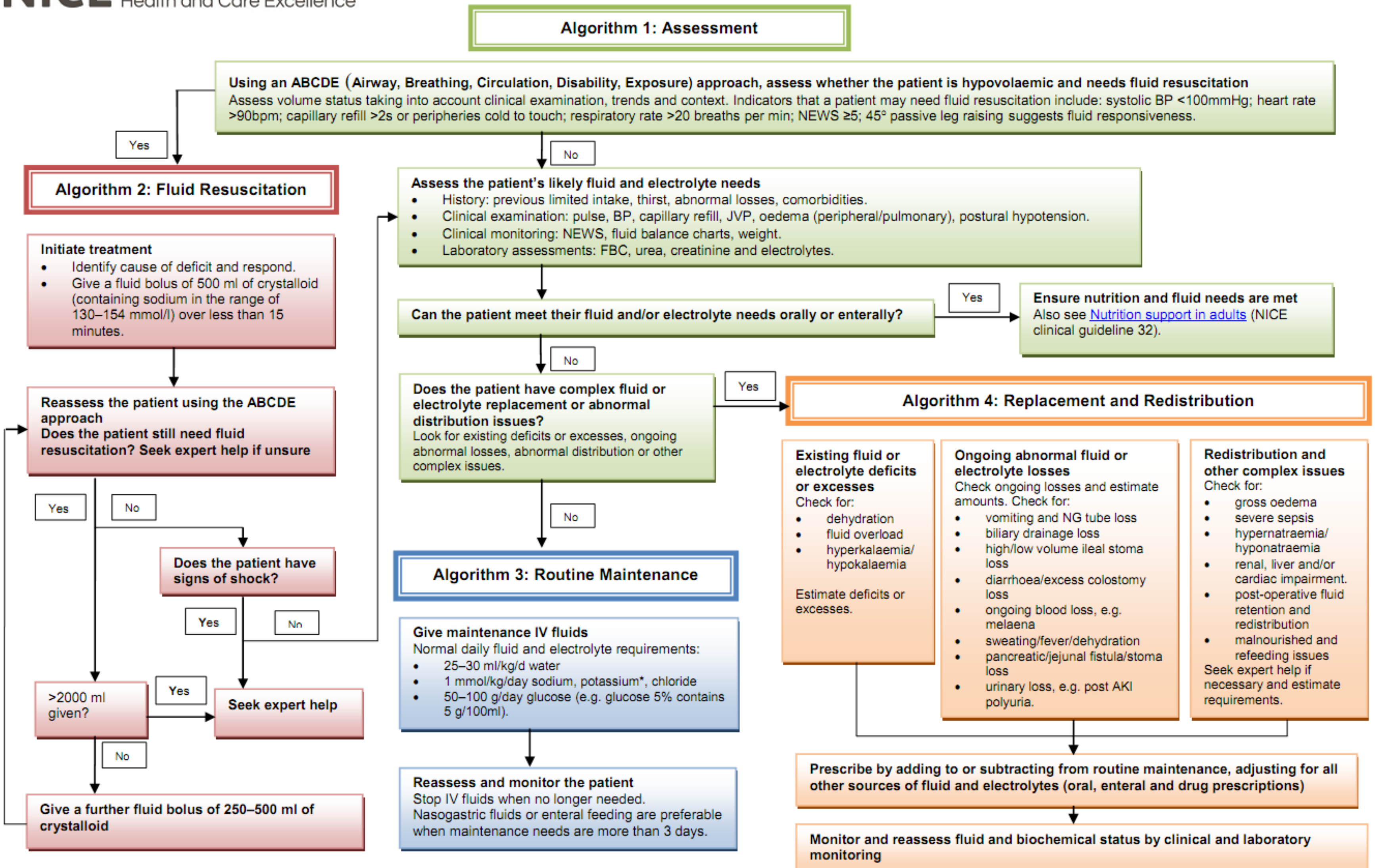
Intravenous fluid therapy in adults in hospital

Clinical guideline

Published: 10 December 2013
www.nice.org.uk/guidance/cg174

NICE National Institute for Health and Care Excellence

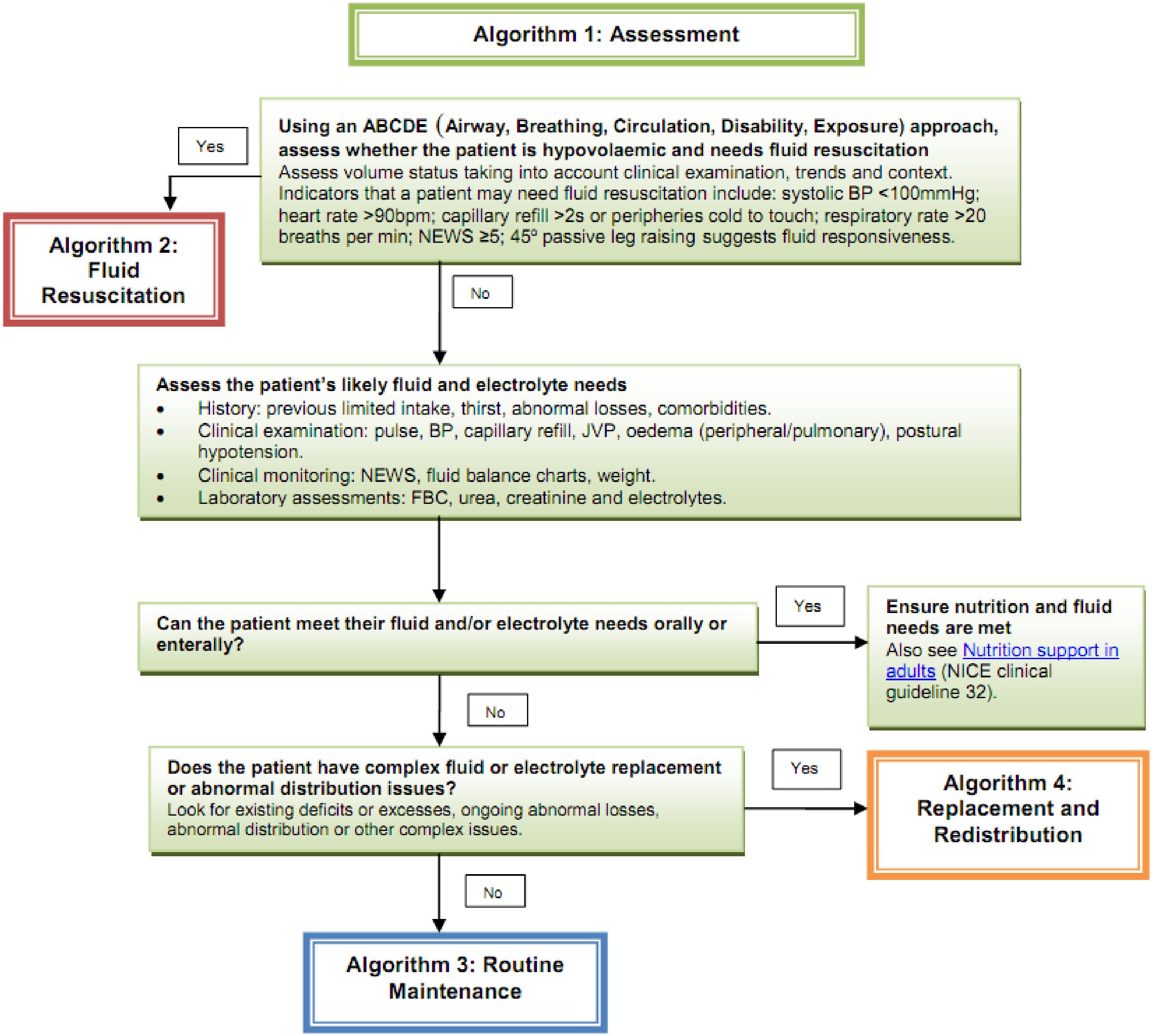
Algorithms for IV fluid therapy in adults

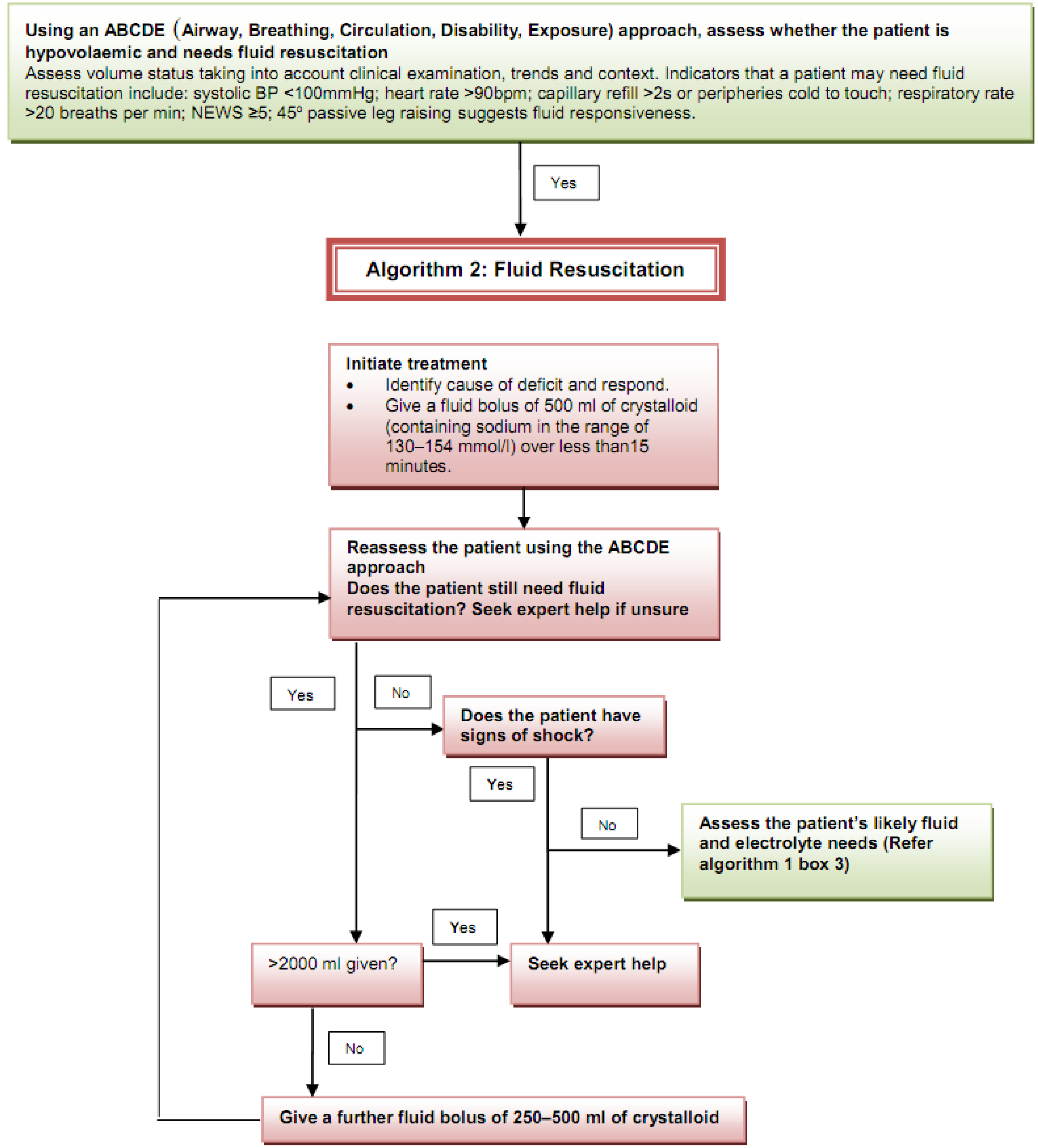


*Weight-based potassium prescriptions should be rounded to the nearest common fluids available (for example, a 67 kg person should have fluids containing 20 mmol and 40 mmol of potassium in a 24-hour period).

Potassium should not be added to intravenous fluid bags as this is dangerous.

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


Algorithm 1: Assessment
Using an ABCDE (Airway, Breathing, Circulation, Disability, Exposure) approach, assess whether the patient is hypovolaemic and needs fluid resuscitation
Assess volume status taking into account clinical examination, trends and context. Indicators that a patient may need fluid resuscitation include: systolic BP <100mmHg; heart rate >90bpm; capillary refill >2s or peripheries cold to touch; respiratory rate >20 breaths per min; NEWS ≥5; 45° passive leg raising suggests fluid responsiveness.
Yes
Algorithm 2: Fluid Resuscitation
No
Assess the patient's likely fluid and electrolyte needs
History: previous limited intake, thirst, abnormal losses, comorbidities.
Clinical examination: pulse, BP, capillary refill, JVP, oedema (peripheral/pulmonary), postural hypotension.
Clinical monitoring: NEWS, fluid balance charts, weight.
Laboratory assessments: FBC, urea, creatinine and electrolytes.
Can the patient meet their fluid and/or electrolyte needs orally or enterally?
Yes
Ensure nutrition and fluid needs are met
Also see Nutrition support in adults (NICE clinical guideline 32).
No
Does the patient have complex fluid or electrolyte replacement or abnormal distribution issues?
Look for existing deficits or excesses, ongoing abnormal losses, abnormal distribution or other complex issues.
Yes
Algorithm 4: Replacement and Redistribution
No
Algorithm 3: Routine Maintenance


Using an ABCDE (Airway, Breathing, Circulation, Disability, Exposure) approach, assess whether the patient is hypovolaemic and needs fluid resuscitation
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Yes
Algorithm 2: Fluid Resuscitation
Initiate treatment
• Identify cause of deficit and respond.
• Give a fluid bolus of 500 ml of crystalloid (containing sodium in the range of 130–154 mmol/l) over less than15 minutes.
Reassess the patient using the ABCDE approach
Does the patient still need fluid resuscitation? Seek expert help if unsure
Yes
No
Does the patient have signs of shock?
Yes
No
Assess the patient's likely fluid and electrolyte needs (Refer algorithm 1 box 3)
Yes
>2000 ml given?
Seek expert help
No
Give a further fluid bolus of 250–500 ml of crystalloid

Using an ABCDE (Airway, Breathing, Circulation, Disability, Exposure) approach, assess whether the patient is hypovolaemic and needs fluid resuscitation
Assess volume status taking into account clinical examination, trends and context. Indicators that a patient may need fluid resuscitation include: systolic BP <100mmHg; heart rate >90bpm; capillary refill >2s or peripheries cold to touch; respiratory rate >20 breaths per min; NEWS ≥5; 45° passive leg raising suggests fluid responsiveness.

Yes

Algorithm 2: Fluid Resuscitation

No

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- Clinical monitoring: NEWS, fluid balance charts, weight.
- Laboratory assessments: FBC, urea, creatinine and electrolytes.

No

Can the patient meet their fluid and/or electrolyte needs orally or enterally?

Yes

Ensure nutrition and fluid needs are met
Also see Nutrition support in adults (NICE clinical guideline 32).

No

Does the patient have complex fluid or electrolyte replacement or abnormal distribution issues?
Look for existing deficits or excesses, ongoing abnormal losses, abnormal distribution or other complex issues.

Yes

Algorithm 4: Replacement and Redistribution

No

Algorithm 3: Routine Maintenance

Give maintenance IV fluids
Normal daily fluid and electrolyte requirements:

- 25–30 ml/kg/d water
- 1 mmol/kg/day sodium, potassium*, chloride
- 50–100 g/day glucose (e.g. glucose 5% contains 5 g/100ml).

Reassess and monitor the patient
Stop IV fluids when no longer needed.
Nasogastric fluids or enteral feeding are preferable when maintenance needs are more than 3 days.

Using an ABCDE (Airway, Breathing, Circulation, Disability, Exposure) approach, assess whether the patient is hypovolaemic and needs fluid resuscitation

Assess volume status taking into account clinical examination, trends and context. Indicators that a patient may need fluid resuscitation include: systolic BP <100mmHg; heart rate >90bpm; capillary refill >2s or peripheries cold to touch; respiratory rate >20 breaths per min; NEWS ≥5; 45° passive leg raising suggests fluid responsiveness.

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- History: previous limited intake, thirst, abnormal losses, comorbidities.
- Clinical examination: pulse, BP, capillary refill, JVP, oedema (peripheral/pulmonary), postural hypotension.
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Can the patient meet their fluid and/or electrolyte needs orally or enterally?

Yes → **Ensure nutrition and fluid needs are met**
Also see Nutrition support in adults (NICE clinical guideline 32).

No

Does the patient have complex fluid or electrolyte replacement or abnormal distribution issues?

Look for existing deficits or excesses, ongoing abnormal losses, abnormal distribution or other complex issues.

Yes

Algorithm 4: Replacement and Redistribution

Existing fluid or electrolyte deficits or excesses

Check for:

- dehydration
- fluid overload
- hyperkalaemia/ hypokalaemia

Estimate deficits or excesses.

Ongoing abnormal fluid or electrolyte losses

Check ongoing losses and estimate amounts. Check for:

- vomiting and NG tube loss
- biliary drainage loss
- high/low volume ileal stoma loss
- diarrhoea/excess colostomy loss
- ongoing blood loss, e.g. melaena
- sweating/fever/dehydration
- pancreatic/jejunal fistula/stoma loss
- urinary loss, e.g. post AKI polyuria.

Redistribution and other complex issues

Check for:

- gross oedema
- severe sepsis
- hypernatraemia/ hyponatraemia
- renal, liver and/or cardiac impairment.
- post-operative fluid retention and redistribution
- malnourished and refeeding issues

Seek expert help if necessary and estimate requirements.

Prescribe by adding to or subtracting from routine maintenance, adjusting for all other sources of fluid and electrolytes (oral, enteral and drug prescriptions)

Monitor and reassess fluid and biochemical status by clinical and laboratory monitoring

PRACTICE

Check for updates

GUIDELINES

Covid-19 and acute kidney injury in hospital: summary of NICE guidelines

Nicholas M Selby *professor of nephrology*[1], Lui G Forni *professor of intensive care medicine*[2], Christopher M Laing *consultant nephrologist*[3], Kerry L Horne *specialist trainee in renal medicine*[4], Rhys DR Evans *specialist trainee in renal medicine*[3], Bethany J Lucas *NIHR academic clinical fellow in renal medicine*[1], Richard J Fluck *consultant nephrologist*[4]

[1]Centre for Kidney Research and Innovation, University of Nottingham, UK; [2]Department of Intensive Care, Royal Surrey County Hospital NHS Foundation Trust and Section of Clinical Medicine, School of Biosciences and Medicine, University of Surrey, Guildford, UK; [3]Department of Renal Medicine, University College London, Royal Free Hospital, London, UK; [4]Department of Renal Medicine, Royal Derby Hospital, Derby, UK

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.

감사합니다.