NANT

Las Vegas, NV

Wednesday, March 23rd, 2016

Anne Diroll, RN, CNN

Fluid Management during Hemodialysis

OBJECTIVES

1. Review consequences of volume overload
2. Discuss conditions for coverage as they relate to volume, anemia and BP
3. Discuss hematocrit-based blood volume removal and fluid removal during hemodialysis
4. Review strategies for safe fluid removal
5. Discuss oxygen saturation and interpretation of values
6. Briefly discuss the dissociation between pressure and volume

Review consequences of fluid overload

OBJECTIVE #1

Why does volume matter?

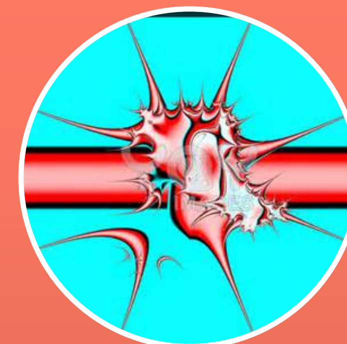
Hypovolemia

- Sepsis
- Overfiltration
- Ascites
- N/V
- Bleeding

Organ Dysfunction
Adverse Outcomes

Normovolemia

- Optimal balance
- Regulated by normal kidney



Hypervolemia

- Underfiltration
- DW underestimated

Organ Dysfunction
Adverse Outcomes

Adapted from: Prowle JR et al. (2009). Fluid balance and acute kidney injury, *Nat. Rev. Nephrol.* 6, 107-115. doi:10.1038/nrneph.2009.213

Volume Overload Contributes to:

- Expanded extracellular volume (ECV)
- Cardiovascular risk (hypertension, LVH, arrhythmias)
- Hypoalbuminemia
- Anemia (hypervolemia dilutes Hgb & Hct)
- Inflammation
- Bowel wall edema, increased gut permeability, increased plasma endotoxin levels
- Dyspnea, coughing, increased respiratory rate
- Hypoxia due to pulmonary vascular congestion
- Rales and wheezing
- Physical inactivity

Reyes-Bahamonde, J et al: (2013) Fluid overload and inflammation – a vicious cycle. Seminars in Dialysis, Vol 26, No 1 pp. 16-39 doi: 10.1111/sdi.12024

Discuss conditions for coverage as they relate to volume, anemia and BP

OBJECTIVE #2

Condition for Coverage

‘manage the patient’s ***volume*** status’

§ 494.90(a)(1)

under the “Patient plan of care” condition

www.cms.gov/Regulations-and-Guidance/Legislation/CFCsAndCoPs

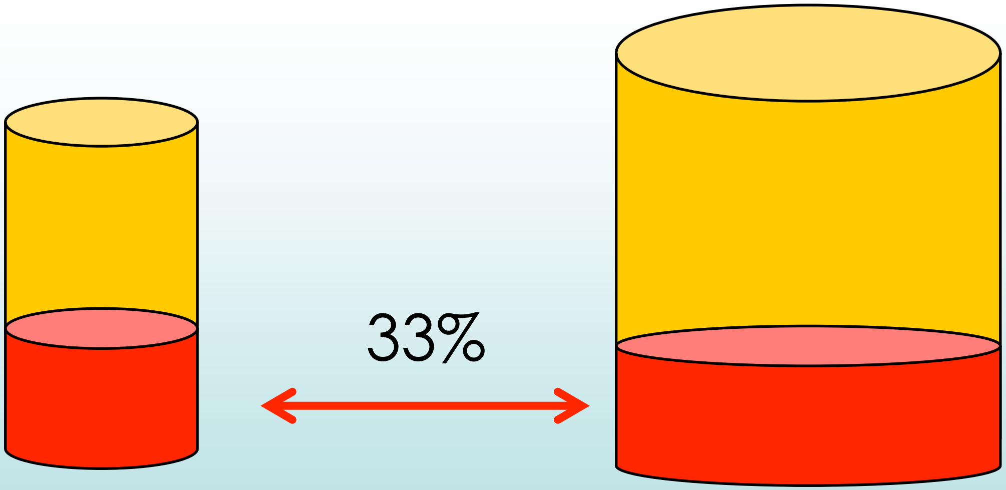
Correlation Grids

V Tag	Patient Assessment § 494.80	V Tag	Plan of Care § 494.90
V504	BP/fluid management needs	V543	Manage BP and volume status
	Interdialytic BP & weight gain Target weight Symptoms Value – Euvolemic & BP 130/80 Peds: BP should be lower of 90% of normal for age/wt/ht or 130/80		Management of volume status Euvolemic and BP 130/80
V507	Anemia	V547	Achieve and sustain Hgb/Hct
	Volume Bleeding Infection ESA hypo-response		Hgb on ESAs 10-12 g/dL Hgb off ESAs >10 g/dL

Adapted from: Centers for Medicare & Medicaid Services – Version 1.3

Anemia: Achieving & Sustaining Hgb/Hct

- Hypervolemia dilutes Hgb AND Hct
- Current ESA therapy does not account for volume
- Hypervolemia increases *inflammation*
- Inflammation contributes to ESA resistance



Reyes-Bahamonde J, Raimann JG, Thijssen S, Levin NW, & Kotanko P. (2013) Fluid Overload and Inflammation—A Vicious Cycle. *Seminars in Dialysis* Vol 26, No 1 (January–February) pp. 16–39 DOI: 10.1111/sdi.12024

Pecoits-Filho, R et al. (2004). Impact of residual renal function on volume status in chronic renal failure. *Blood Purif*. 22(3):285-92.

Amgen Package insert.

CfC

TAG NUMBER: V504

REGULATION: Blood pressure, and fluid management needs.

INTERPRETIVE GUIDANCE

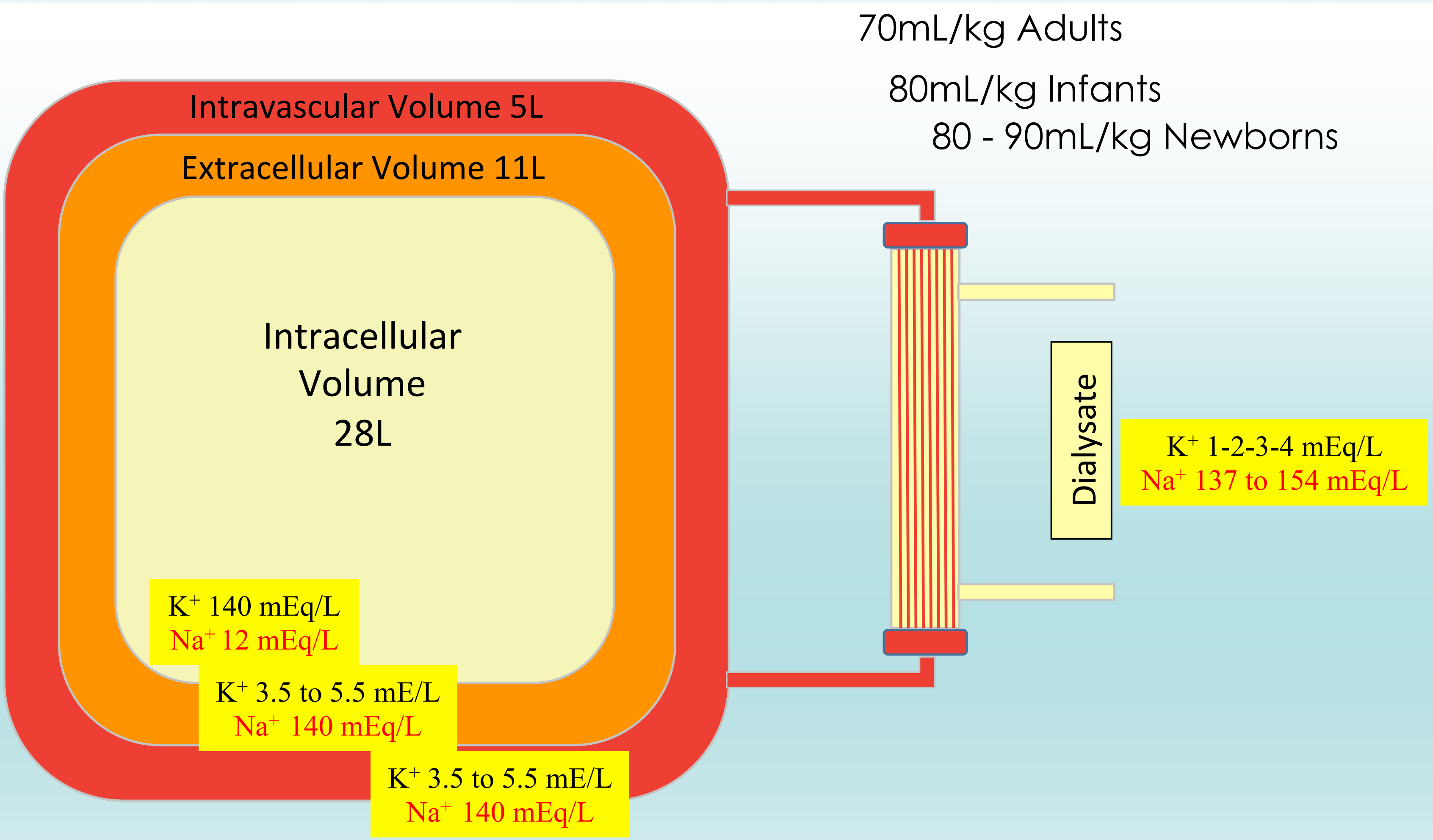
- Because of the adverse effects of ESRD, many patients experience lability of blood pressure and fluid management, the management of which may require reassessment of medication needs, adjustments in target weight, and changes to the POC.
- The comprehensive assessment should include evaluation of the patient's pre/intra/post and interdialytic blood pressures, interdialytic weight gains, target weight, and related intradialytic symptoms (e.g., hypertension, hypotension, muscular cramping) along with an analysis for potential root causes.

(pg 189 of 299. October 2008) www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGeninfo/downloads//SCletter09-01.pdf

Discuss hematocrit-based blood volume removal and fluid removal during hemodialysis

OBJECTIVE #3

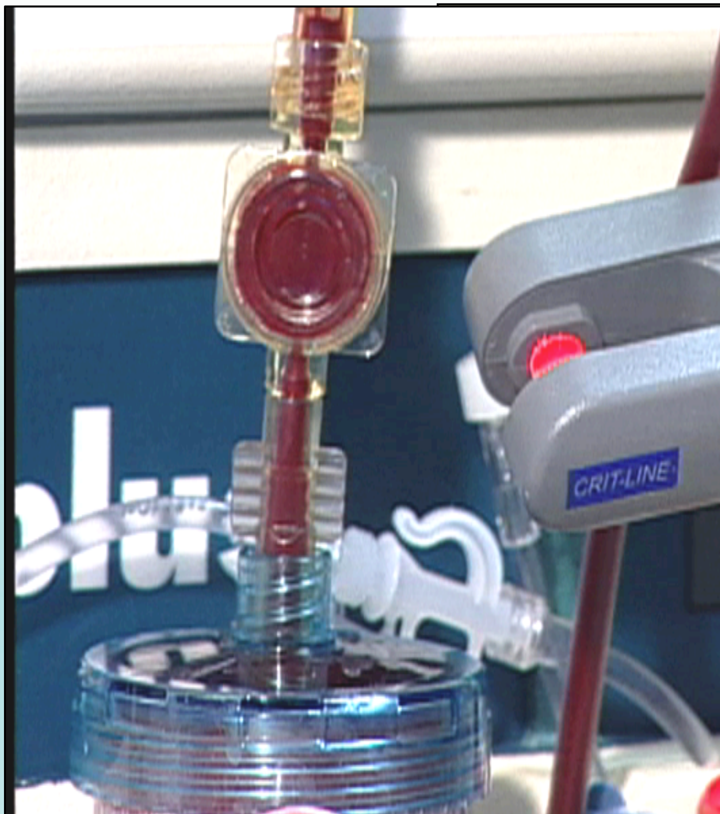
4-Compartment Fluid Model

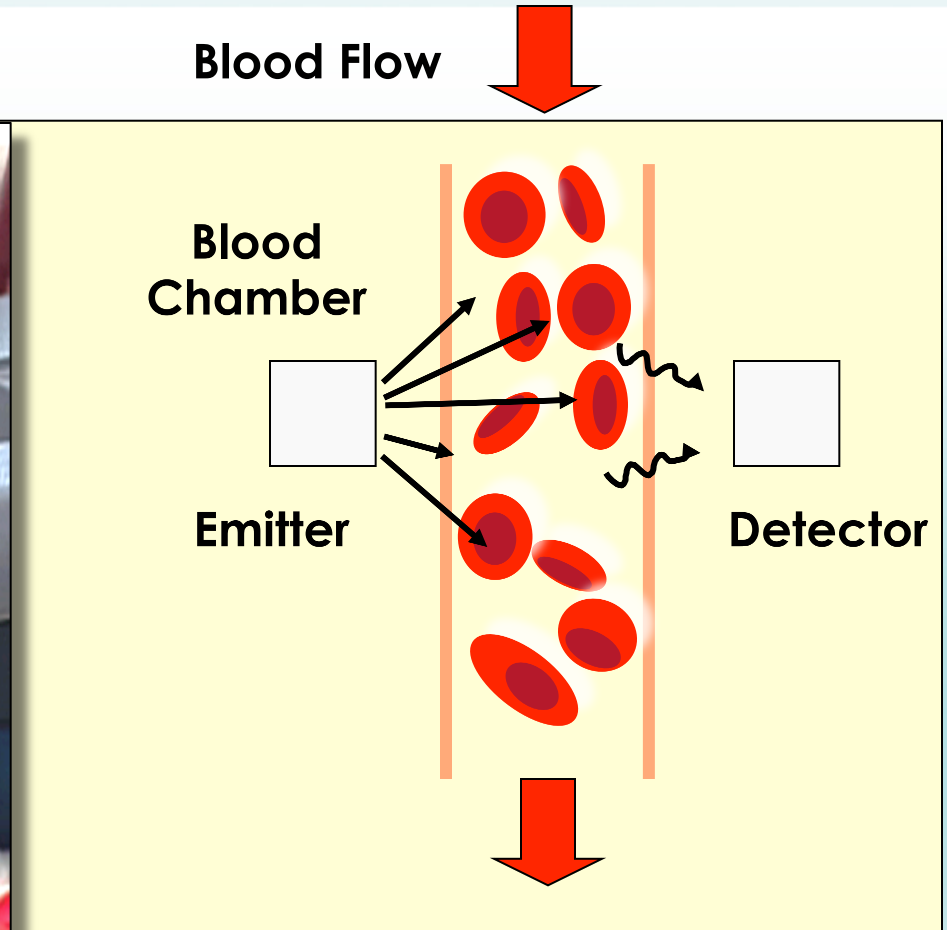


Adapted from Ahmad, S. (1999). Fluid Movements in relation to ultrafiltration. In M. Knowles (Ed.), *Manual of clinical dialysis* (p. 32). London.Science Press Ltd.

Bonanno, FG. *Hemorrhagic shock: The "physiology approach"* J Emerg Trauma Shock. 2012 Oct-Dec; 5(4): 285-295 doi: 10.4103/0974-2700.102357

NIVM Technology



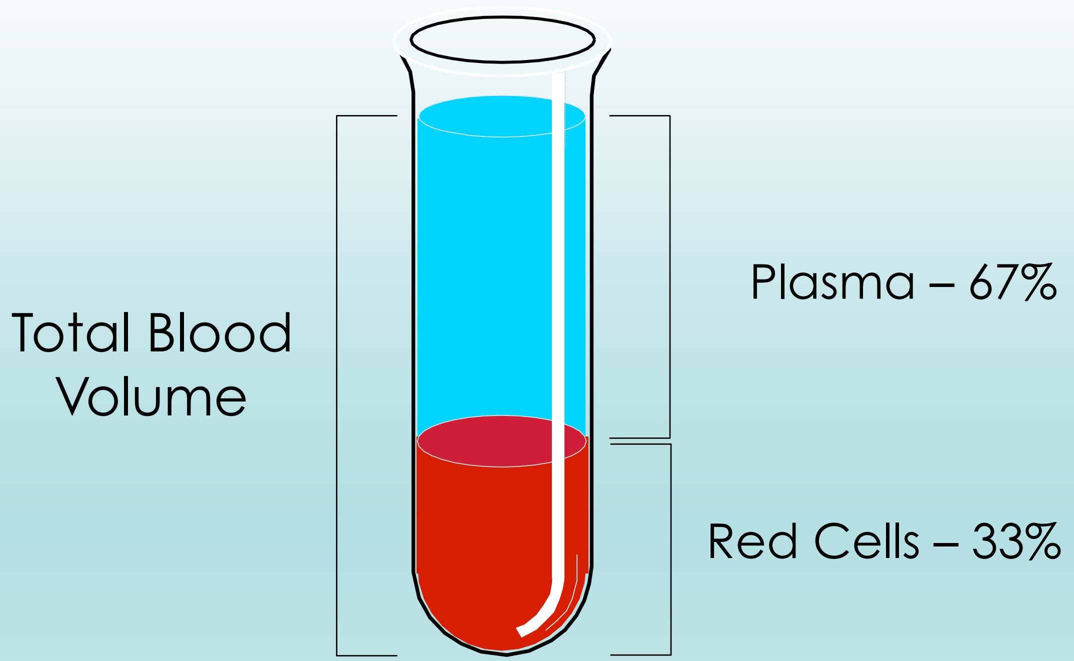


Absolute O_2 saturation

Absolute Hct → Hgb est → BV calculated → (St Hct/Current Hct -1) X 100 = BVΔ%

Fundamental Parameter: Hematocrit

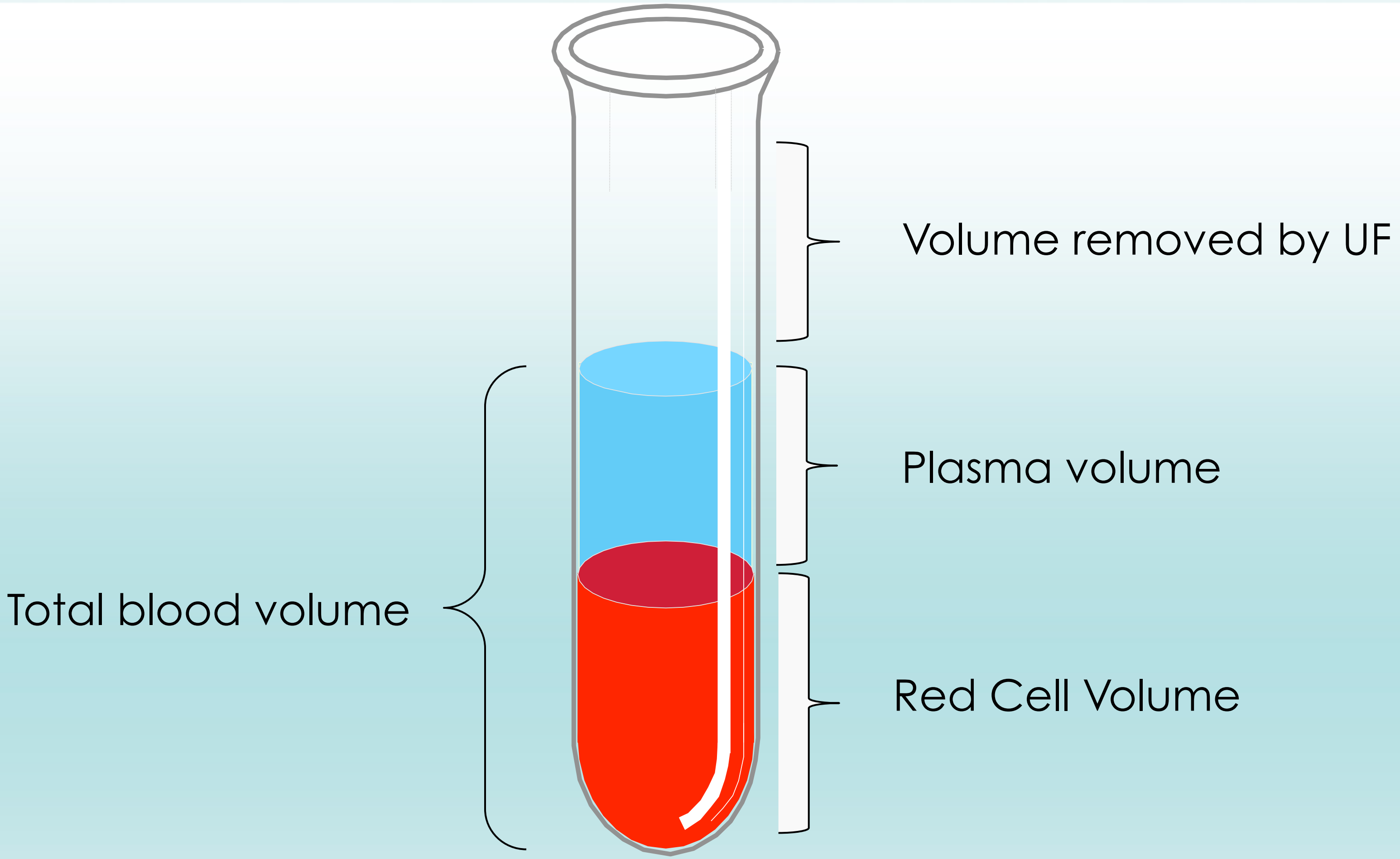
Test tube represents circulating blood volume – what is the hematocrit?



Adapted from: Guyton & Hall, *Textbook of Medical Physiology*, 10th ed, 2000

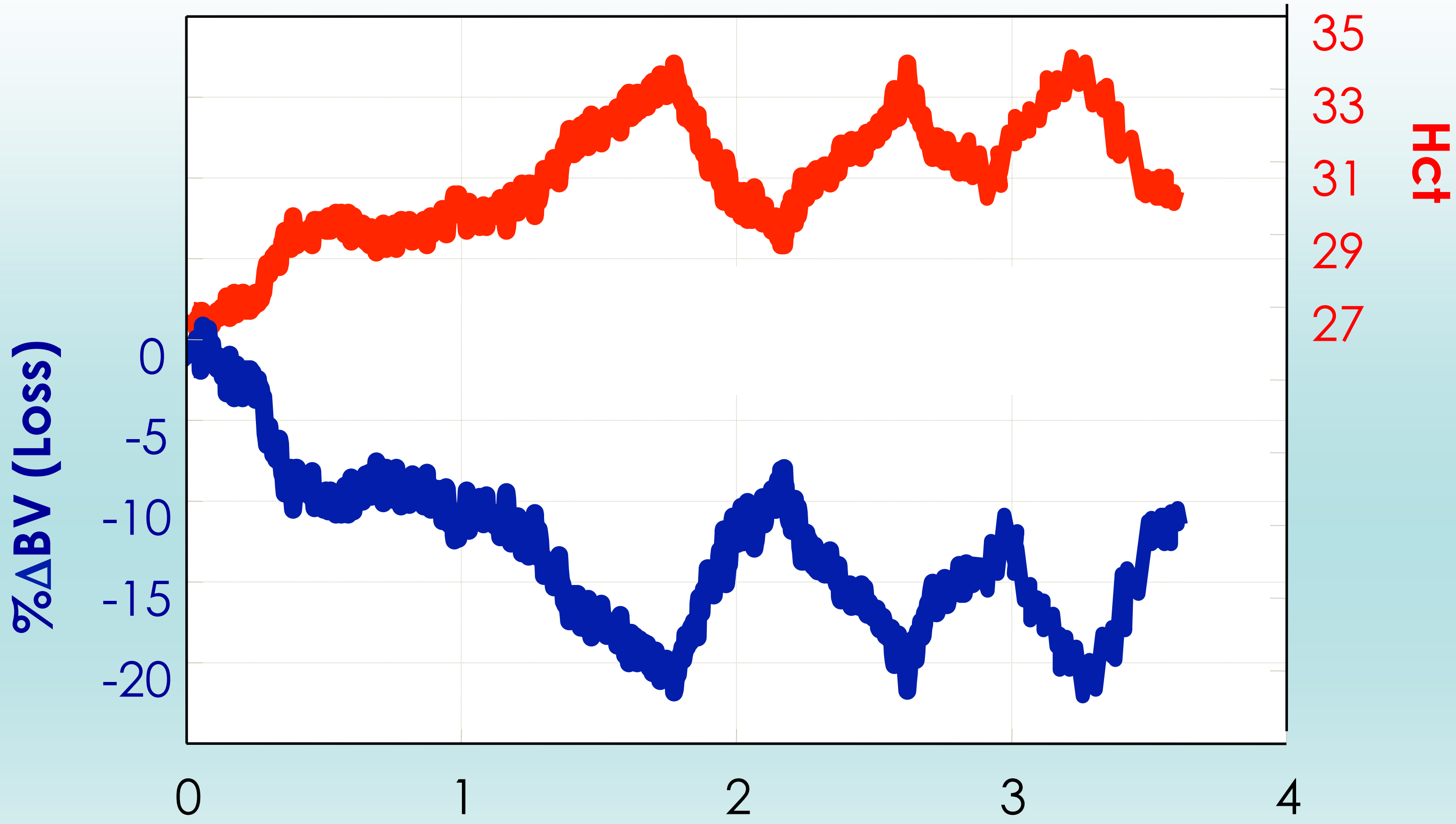
Boyle, A., Sobotka,PA. (2006) Redefining the therapeutic objective in decompensated heart failure: Hemoconcentration as a surrogate for plasma refill rate. *Journal of Cardiac Failure*,Vol.12, No.4

What is the hematocrit?



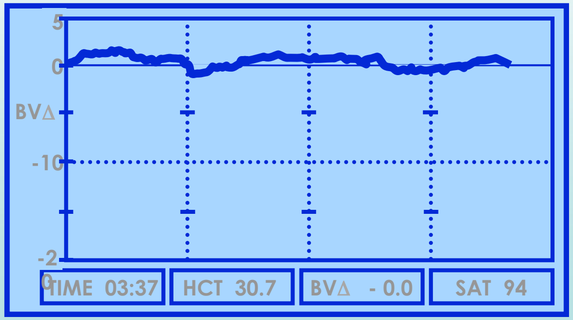
Adapted from: Guyton & Hall, *Textbook of Medical Physiology*, 10th ed, 2000

Hematocrit and Blood Volume

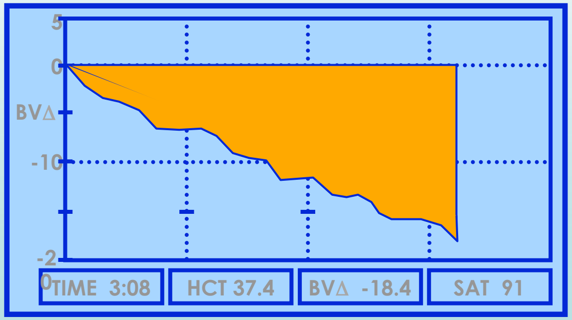


Fluid Removal Profiles

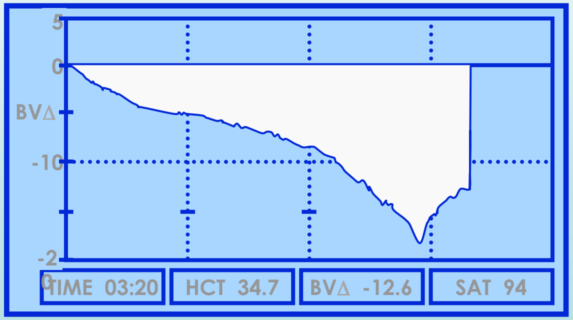
BV Profile A



BV Profile B



BV Profile C



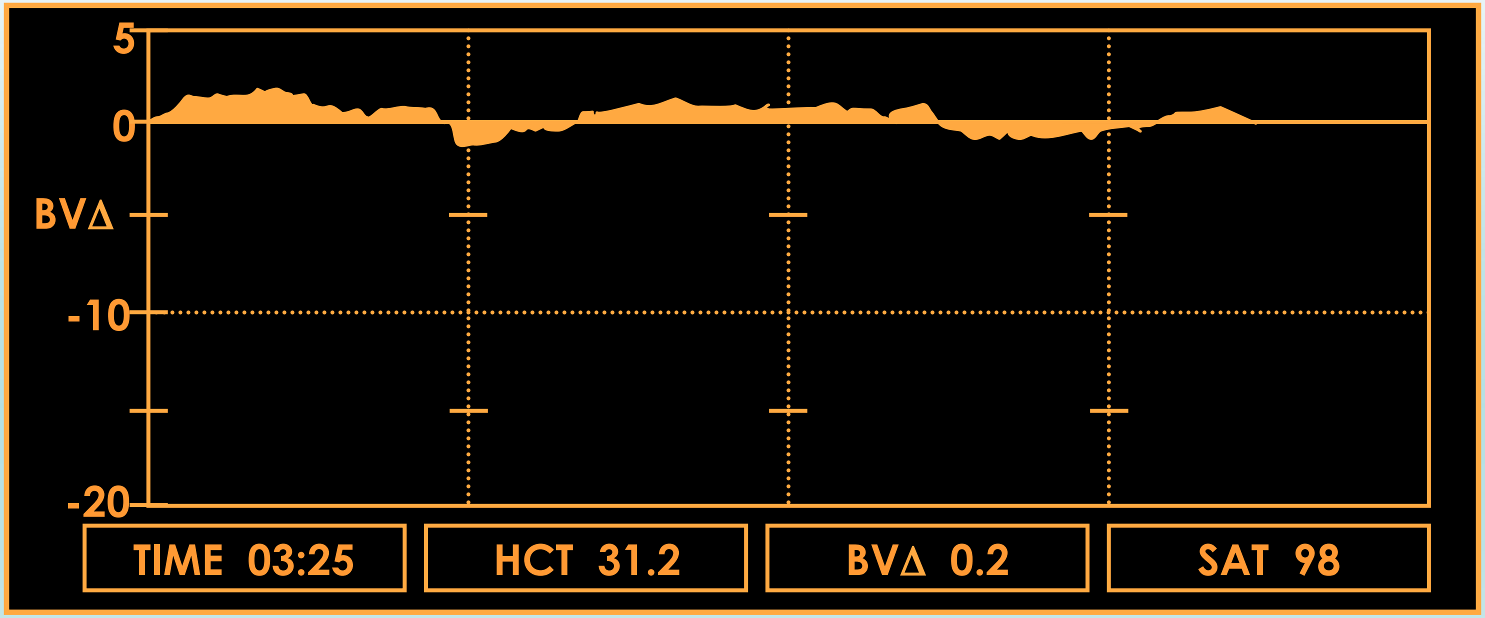
Adapted from Crit-Line® Fresenius Medical Care, Waltham, MA 02541

Profile A

<3% per hour.

↑UFR

Possible Exceptions: Residual Renal Function, Heart Failure



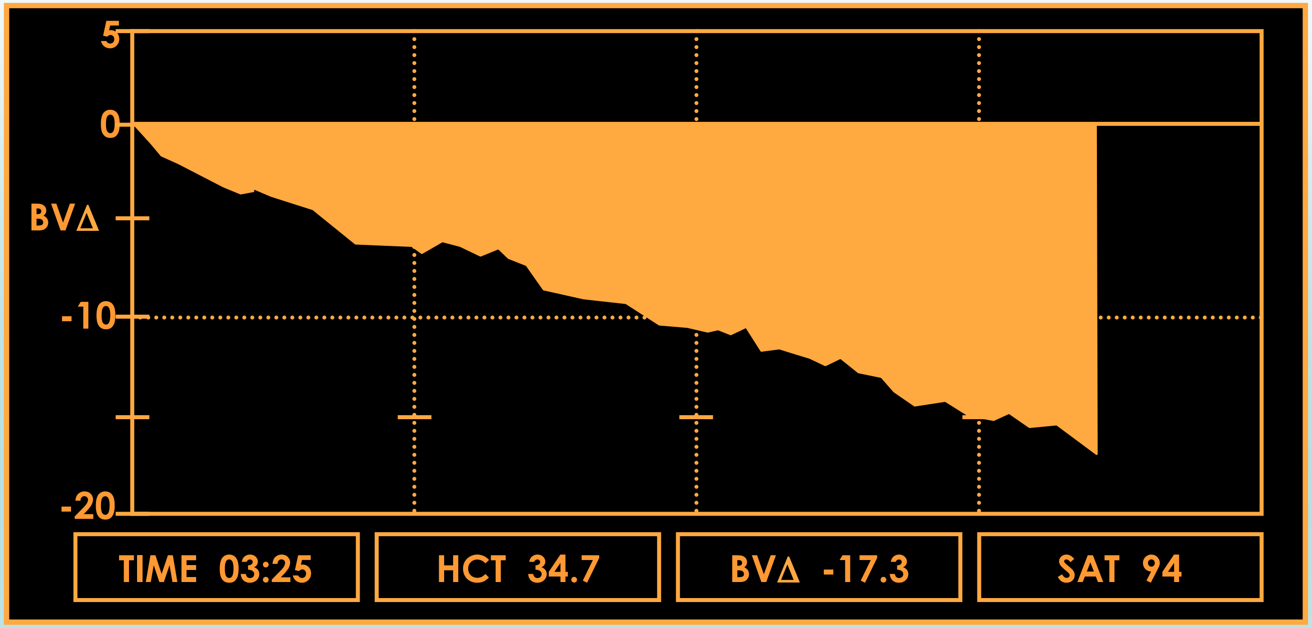
Agarwal, R. (2010)Hypervolemia is associated with increased mortality among hemodialysis patients. Hypertension. 56: 512-517

Profile B

3 to 8% per hour

Maintain UFR

Not to exceed a maximum total BV Change of -15% to -16%

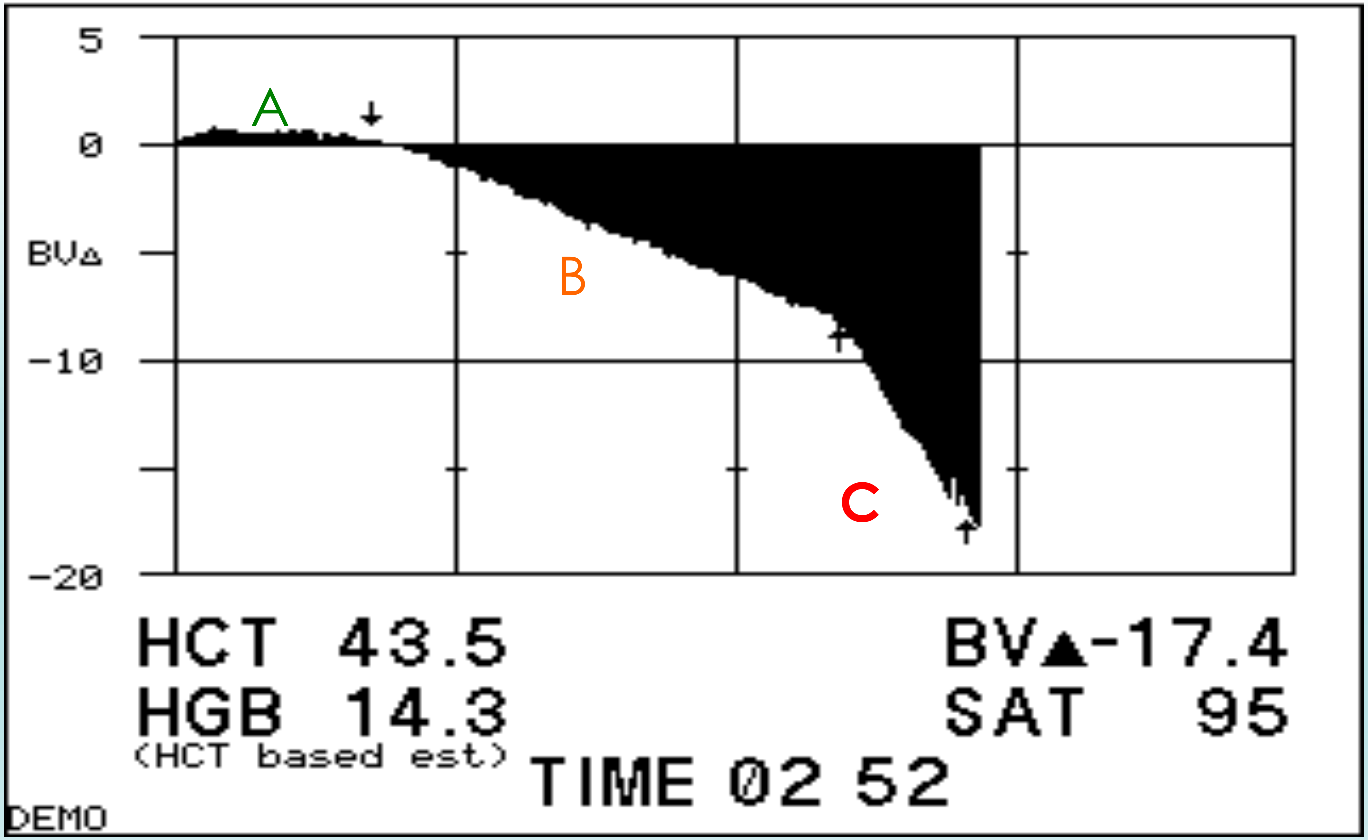


Rodriguez,H, Domenici,R, Diroll,A, Goykhman,I: Assessment of DW by monitoring changes in BV during HD using Crit-Line, Kidney International,Vol.68(2005),pp.854-861
Goldstein, Smith, Currier. (2003) Non-invasive interventions to decrease hospitalization and associated costs for pediatric patients receiving hemodialysis.JASN. 14:2127-2131

Profile C

> 8% per hour

Decrease UF Rate



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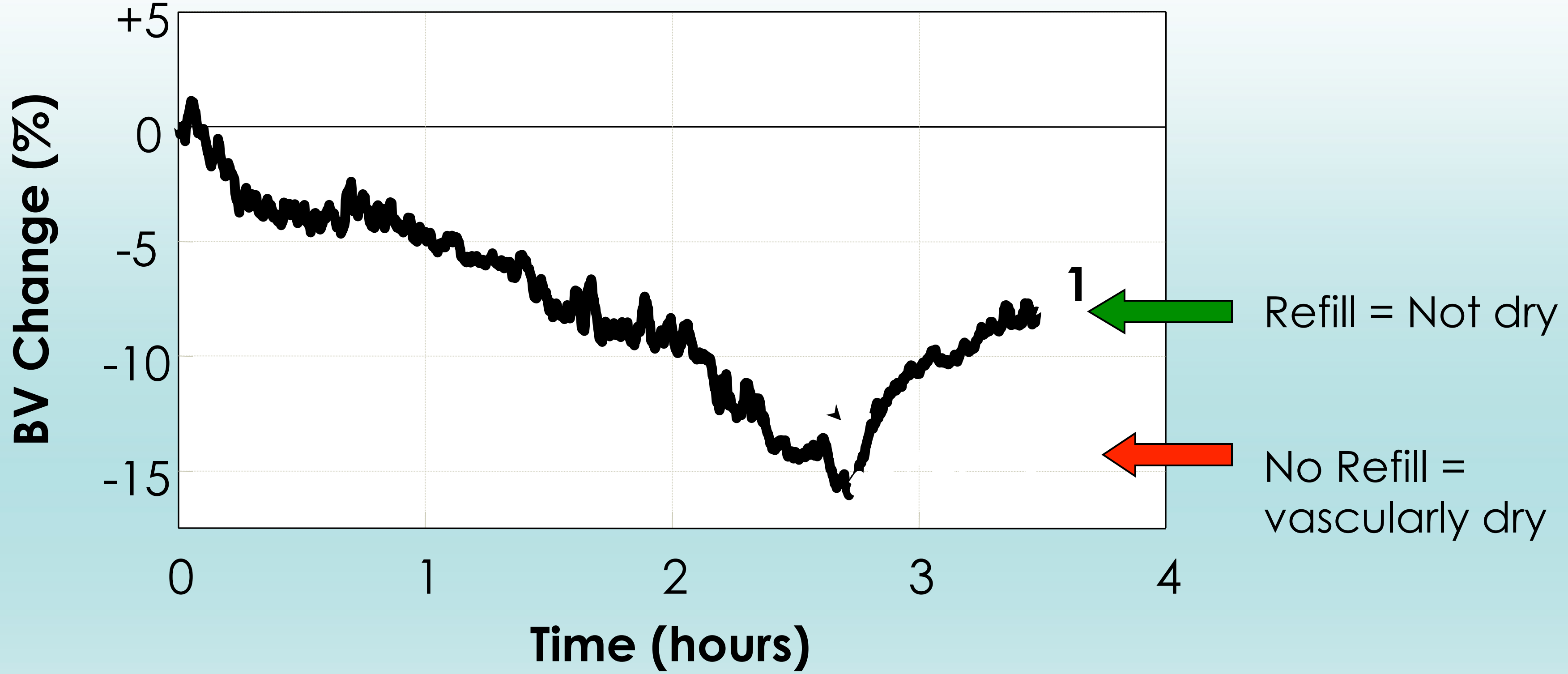
Goldstein, Smith, Currier. (2003) Non-invasive interventions to decrease hospitalization and associated costs for pediatric patients receiving hemodialysis.JASN. 14:2127-2131

Refill: Indicator of Target Weight



Rodriguez,H, Domenici,R, Diroll,A, Goykhman,I: Assessment of DW by monitoring changes in BV during HD using Crit-Line, Kidney International,Vol.68(2005),pp.854-861

Refill Check

- Note current Hematocrit
- Change UFR to minimum
- Wait 10 minutes
- Note Hematocrit again
- If Hct goes down by 0.5 or more in 10 mins or less, pt has refill - example: 37.5 to 37.0
- If Hct goes down by 0.4 or less in 10 mins, pt is dry - example: 37.5 to 37.1

Rodriguez,H, Domenici,R, Diroll,A, Goykhman,I: Assessment of DW by monitoring changes in BV during HD using Crit-Line, Kidney International,Vol.68(2005),pp.854-861

Refill Interventions

Blood volume reduction	Postdialytic vascular refill	Sx of hypovolemia/ postdialysis fatigue	Dry weight change
Yes	No	No	No
Yes	No	Yes	Revise up
Yes	Yes	No	Revise down
Yes	Yes	Yes	Revise down*
No	No	No	Revise down

*Achieving dry weight in these patients requires individualizing dialysis treatments by changes in blood flow, duration of sessions, ultrafiltration modeling, monitoring of oxygen saturation, and the use of colloid solutions.

Rodriguez H, Domenici R, Diroll A, Goykhman I: *Assessment of dry weight by monitoring changes in blood volume during hemodialysis using Crit-Line*. Kidney International, *Vol 68 (2005), pp 854-861*

Complications

- Blood leak
- Inaccurate hematocrit.

  Too low due to saline or air in blood chamber

  Too high due to recirculation or clotting
- Ignoring rapidly declining BV or $ScvO_2$ because patient is asymptomatic or BP is normal

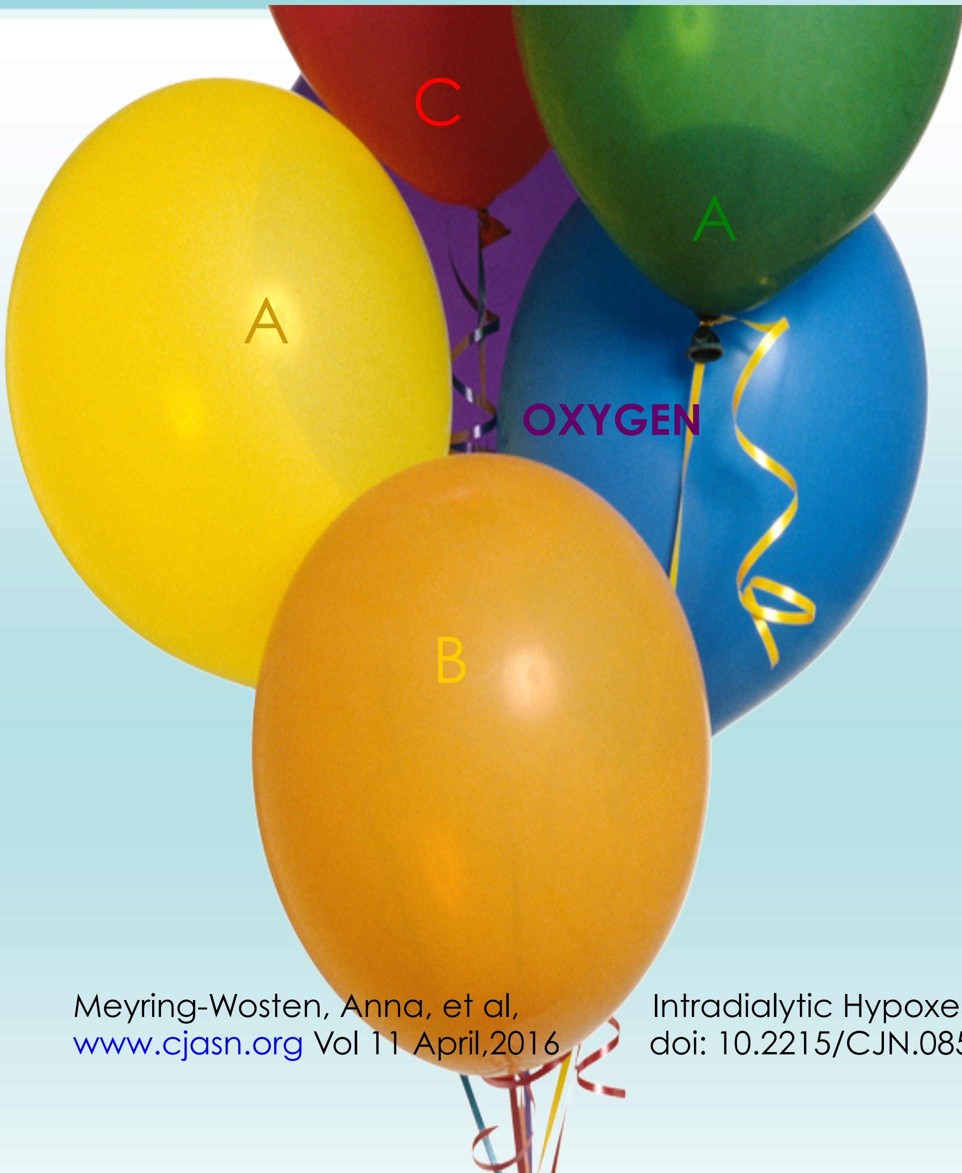
A stable BP in the event of BV declination is due to cardiovascular and neurohormonal compensation


Elapsed Time
00:44:19
Initial Hct: 17.1
Initial est. Hb: 5.8
Profile
C
Tx Running
RTD
2:16
5
0
-5
ΔBV%
-10
-15
-20
100
90
Sat
80
70
1-Hr
2-Hr
3-Hr
Hct
19.4
est. Hb
6.6
ΔBV%
-11.7
O2 Sat
99.9
Min O2 Sat
93.8
BV Alert Level
-16 %
O2 Alert Level
70 %
Art Press -20
Ven Press 20
TMP 40
UF Goal 1000
UF Rate 260
UF Rmvd 361
Dial Flow 400
Temp 37.0
Cond 13.3
Blood Flow 200
Hep Rate 0.0
Kecn 182
Markers
Home
Trends
Dialysate
Test & Options
Heparin
Kt/V AF
Crit-Line
Blood Pressure

Review strategies for safe fluid removal

OBJECTIVE #4

Profile A-B-C



A <3% reduction per hour
↑UFR (unless RRF)

B 3 to 8% reduction per hour, not to exceed total of -16%

C >8% reduction per hour
↓UFR, off/min

SaO_2 >90%

SvO_2 60 to 80%

Meyring-Wosten, Anna, et al, Intradialytic Hypoxemia & Clinical Outcomes in Patients on Hemodialysis
www.cjasn.org Vol 11 April,2016 doi: 10.2215/CJN.08510815

Impact of Loss of Blood Volume

Loss of Blood Volume	MAP - immediate response	Likely Result
5-10%	Little change	Little change Spontaneous recovery
15-20%	80-90 mm Hg	Moderate hypotension
>20%	60-80 mm Hg	Early shock Usually reversible

Smith JJ, Kampine JP. *Circulatory Physiology-the essentials*. 3rd ed. Ch 13. Circulatory Response to Nonexercise Stress. Pg 267.1990.Williams & Wilkins, Baltimore

Determined by specific unit policy

Example:

- Remove 50% of fluid in 1^{st} hr of tx, with max BV reduction limited to 8 to 12% in 1^{st} hr
- Remove second 50% of goal in remaining tx time, with max reduction in BV limited to 5% in the 2^{nd}, 3^{rd}, 4^{th} hours
- Assess for plasma refill weekly, and adjust DW accordingly

Patel et al, (2007) Improved BP control using non-invasive monitoring of hematocrit. *Clin J Am Soc Nephrol* 2:252-257

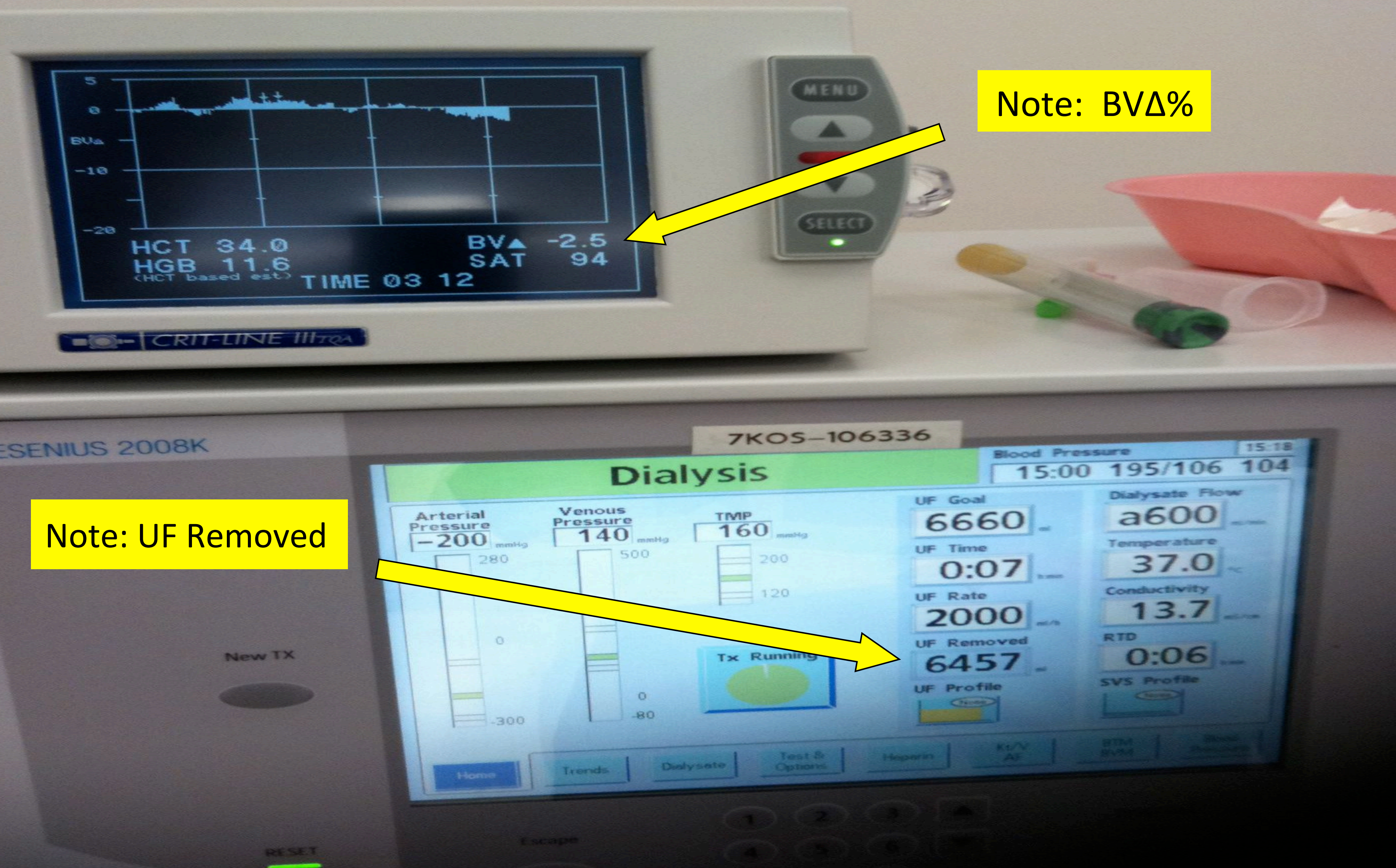
Fluid Removal during Hemodialysis

- <5% of child's pre-dialysis weight
- Accurate assessment of intravascular volume optimizes ultrafiltration in children
- Maximum total blood volume reduction not to exceed 16%
- UFR titrated to achieve targeted blood volume not to exceed 8 to 12% reduction in 1st hour
- Subsequent hours result in no more than 4 to 5% blood volume reduction per hour

Patel et al, (2007) Improved BP control using non-invasive monitoring of hematocrit. *Clin J Am Soc Nephrol* 2:252-257

Fluid overload contributes to high BP

BP 195/106 with UF Removed 6457 mL & Blood Volume Reduction 2.5%

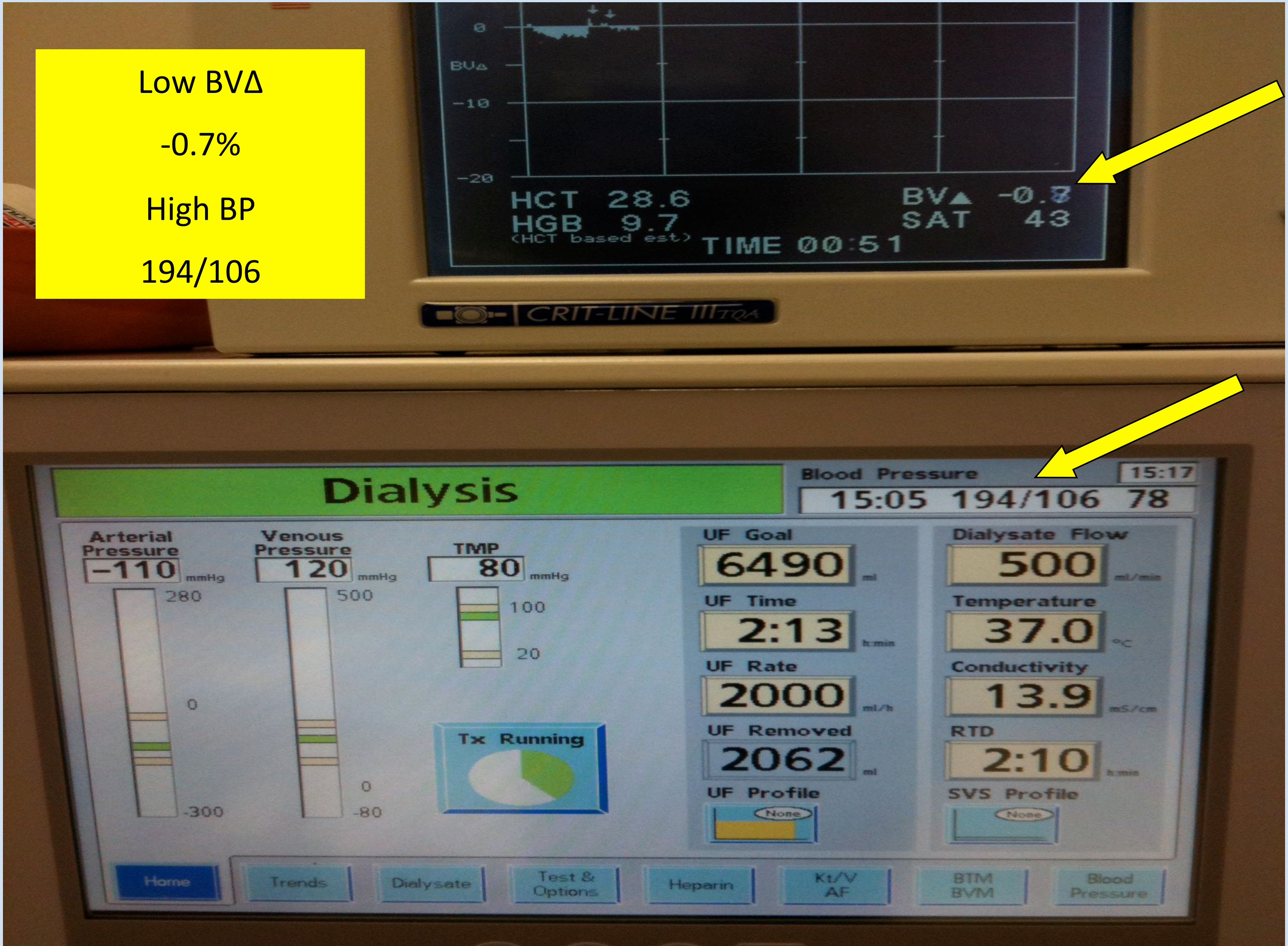


Low BVΔ

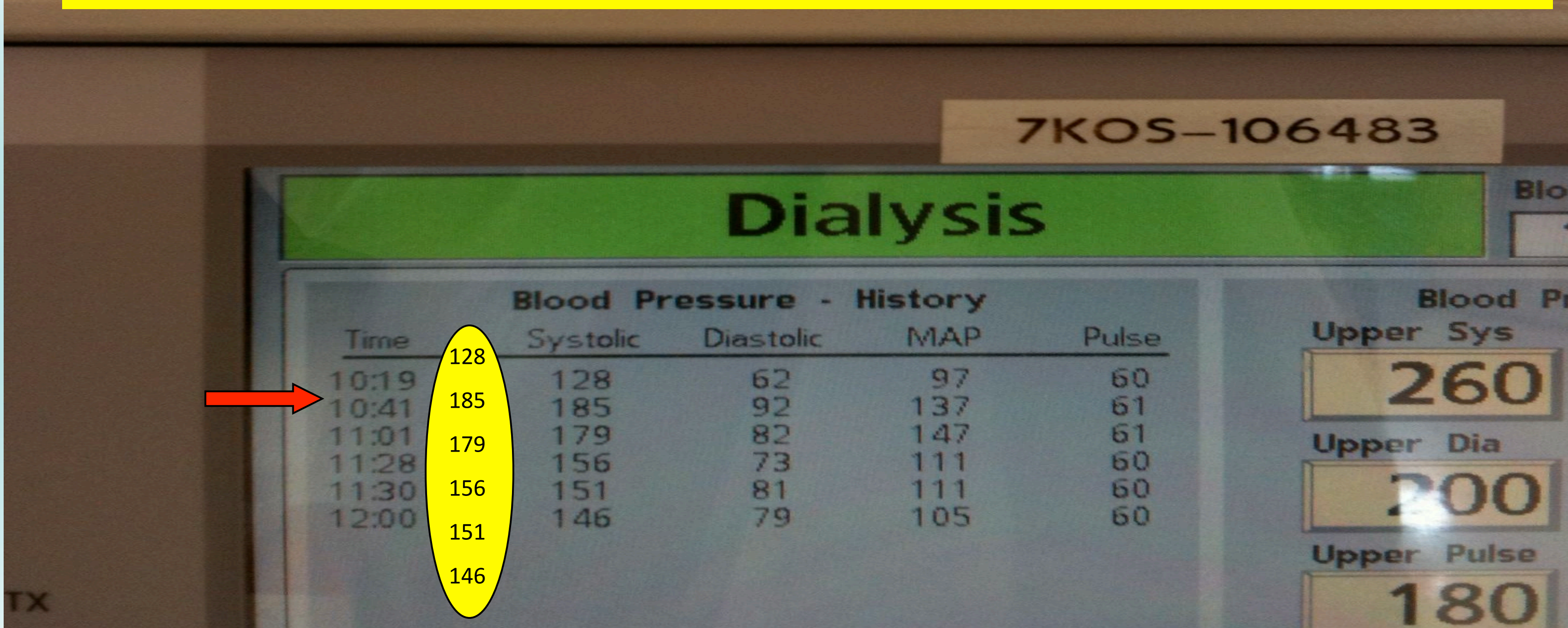
-0.7%

High BP

194/106



20 min into treatment BP ↑to 185/92. Refill check done. No refill. UF left in minimum for remainder of dialysis time. Outcome: BP improves. Patient has Residual Renal Function.Increased BP due to decreased BV.



14 y.o

Male

Hx: HTN

Cramping

Voids 4X/ day

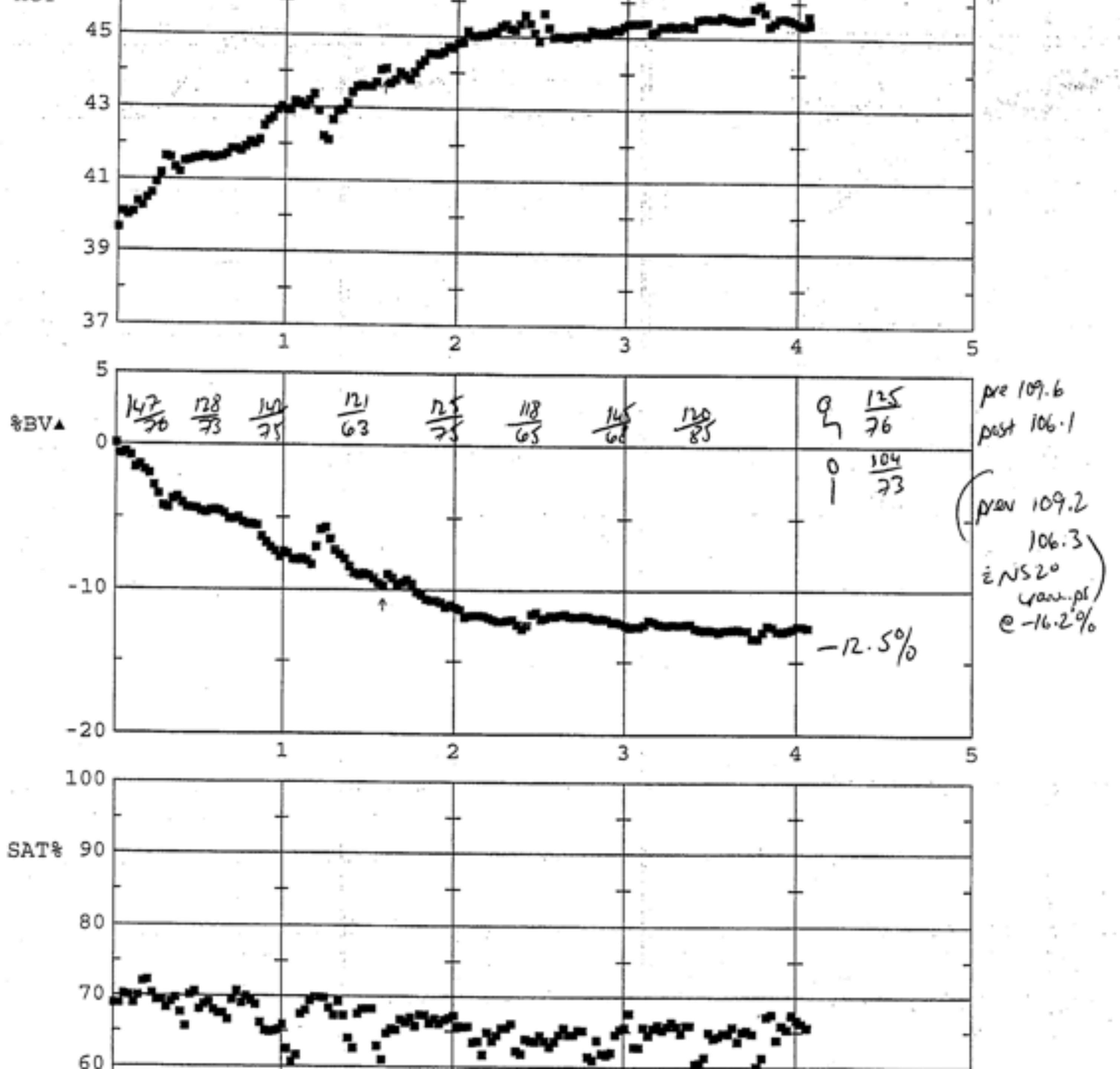
Unknown amount

Hct (start) 39.6 %

Hct (max) 45.9 %

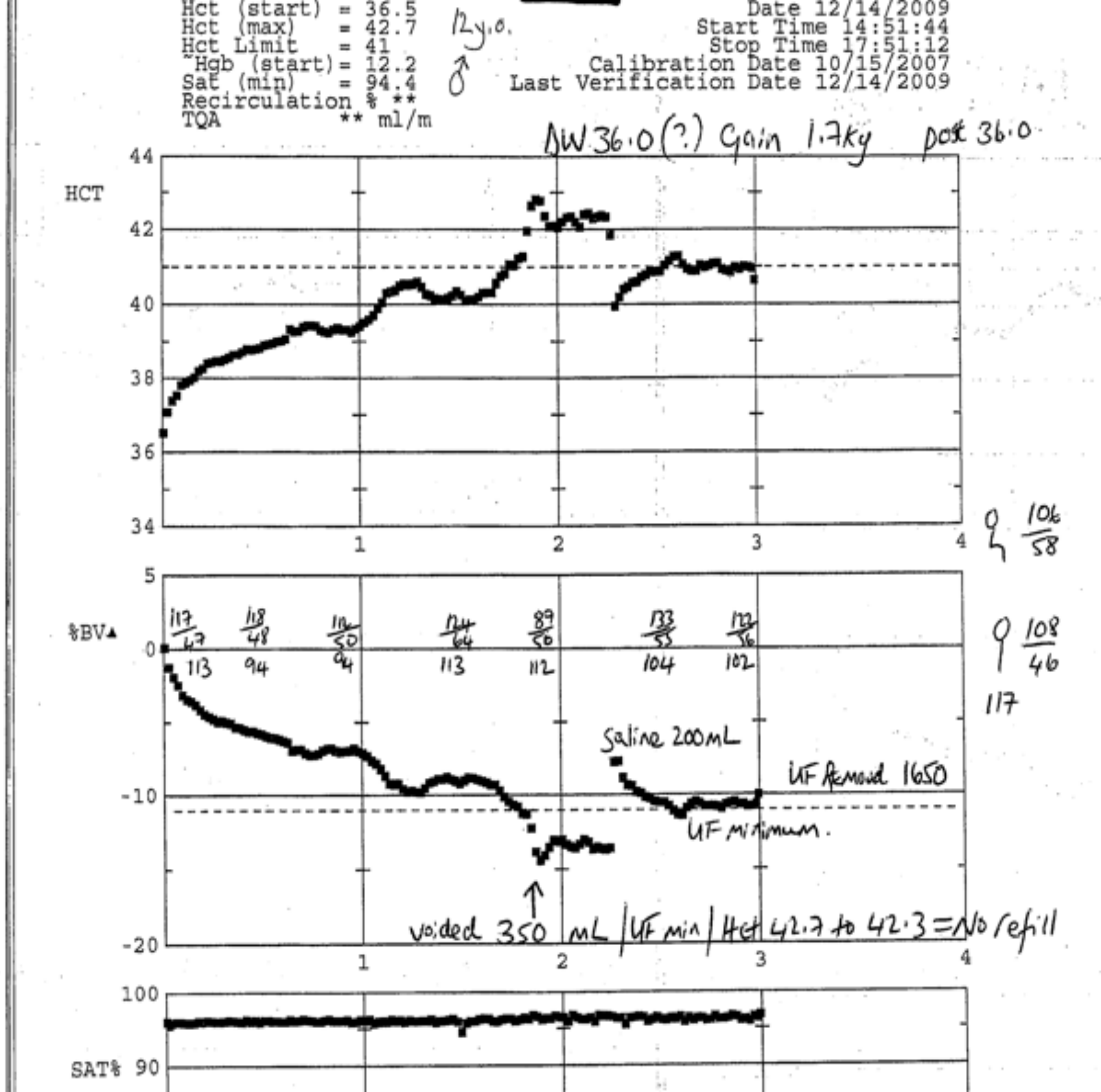
Hgb (start) 13.2 gm/dL

Sat(min)60 %



12 yr old

Male



Discuss oxygen saturation and interpretation of values

OBJECTIVE #5

Clinical Practice Guidelines

Used with permission AARC

INDICATIONS:

1. Documented hypoxemia.

Defined as SaO_2 of < 90% in subjects breathing room air.

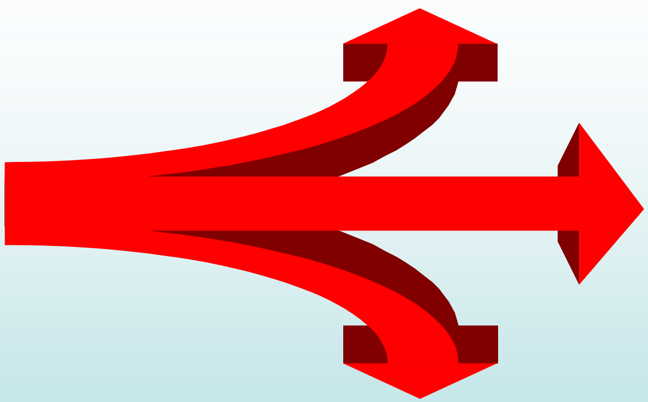
2. An acute care situation in which hypoxemia is suspected.

CONTRAINDICATIONS:

No specific contraindications to oxygen therapy exist when indications are judged to be present.

Respiratory Care 2002;47(6):717-720 AARC Clinical Practice Guideline. Oxygen Therapy for Adults in the Acute Care Facility. Revision & Update

FISTULAE & GRAFTS

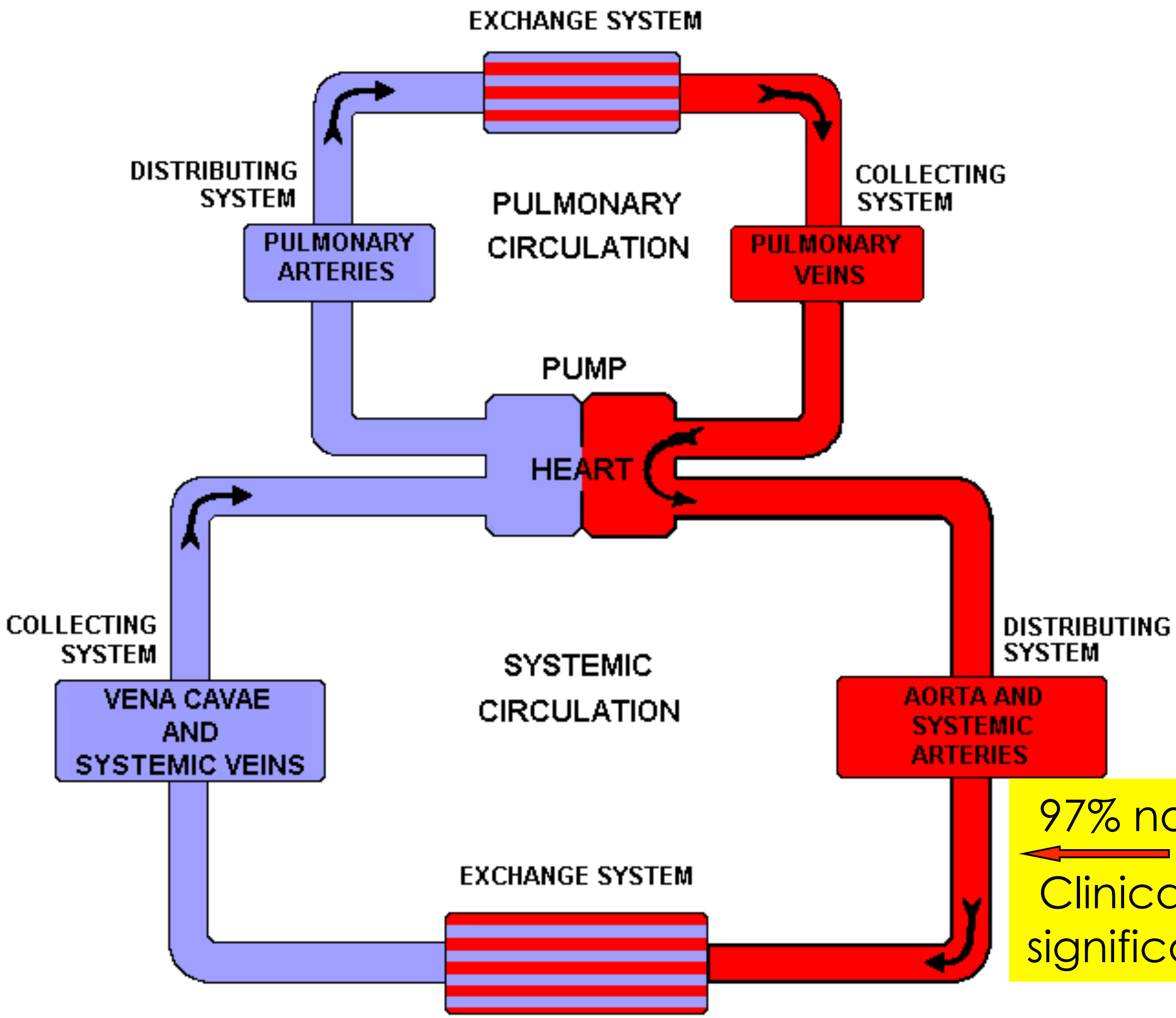


- Arterial Blood
- Normal value 97%
- Clinically significant if <90%

Smith, JJ, Kampine, JP *Circulatory Physiology - the essentials* Third Edition. Williams & Wilkins. ISBN 0-683-07775-9Chapter 1, Blood and the Circulation Page 13.

Respiratory Care 2002;47(6):717-720]AARC Clinical Practice Guideline. Oxygen Therapy for Adults in the Acute Care Facility. Revision & Update

Carbon dioxide ⬉ ⬋ Oxygen



97% normal art sat

Clinically significant if <90%

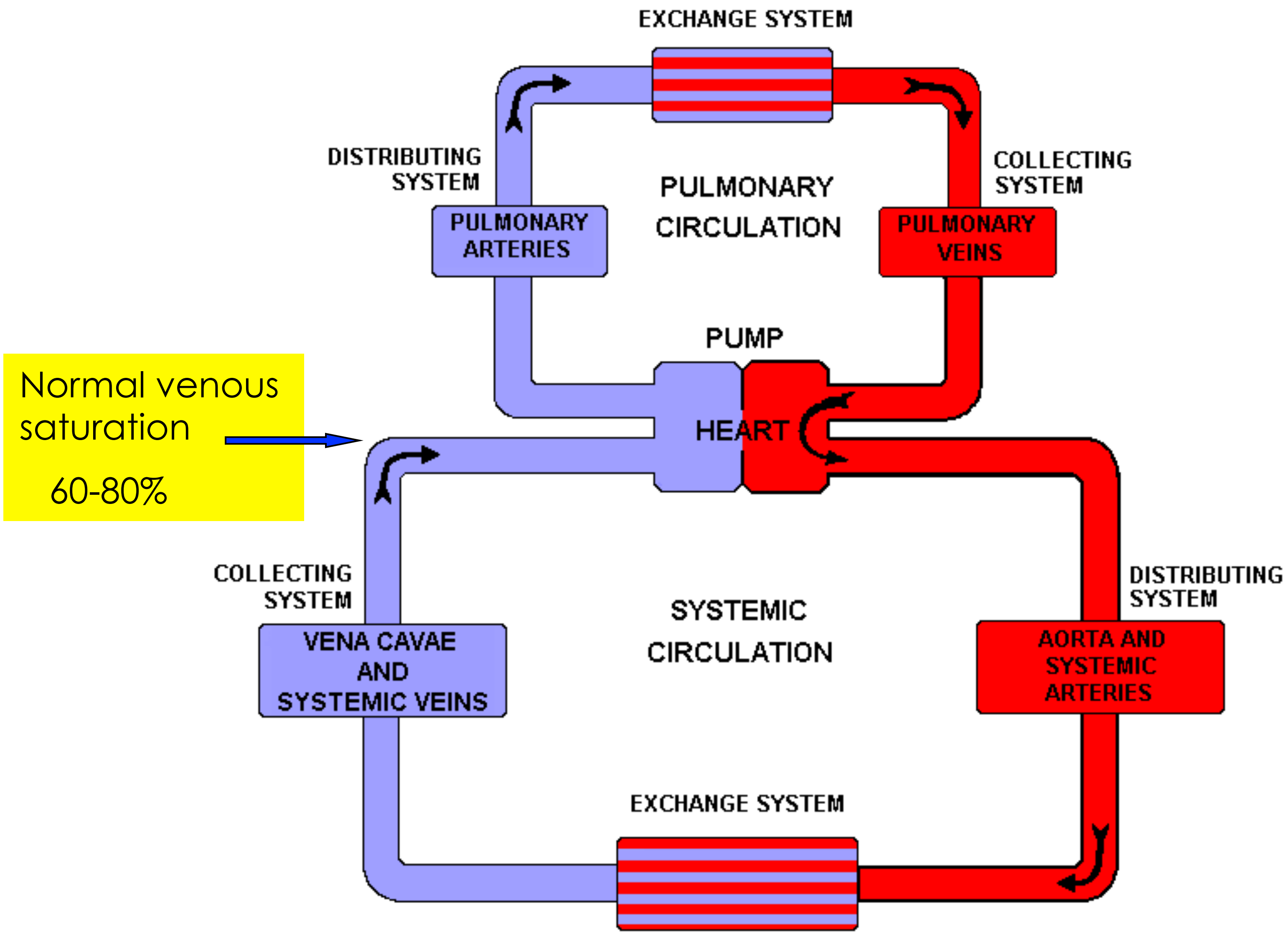
Adapted from: Smith JJ, Kampine JP. **Circulatory Physiology - the essentials.** 3rd ed.1990. Williams & Wilkins, Baltimore. Chapter 1, page 3.

CATHETERS

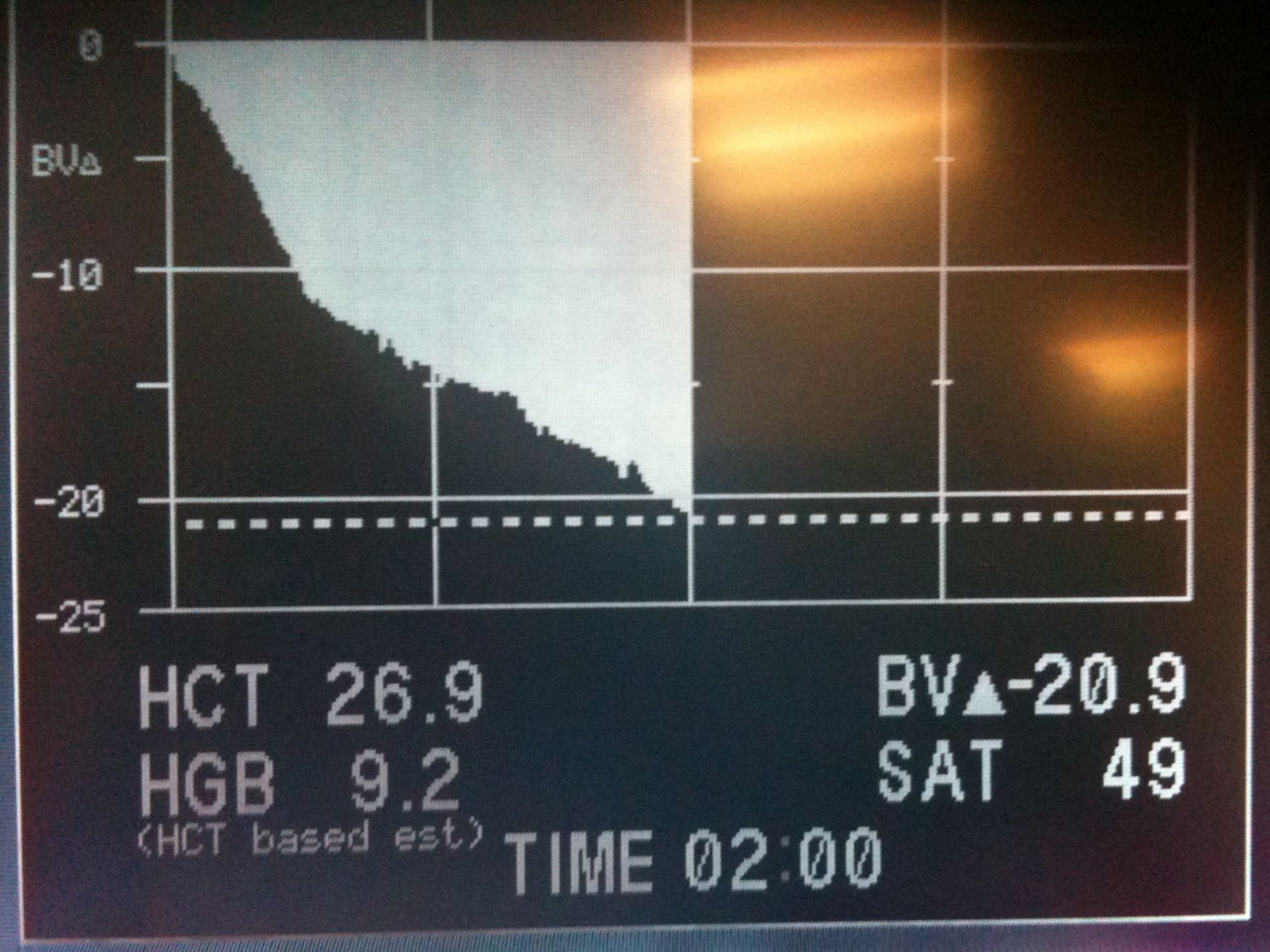
- Mixed Venous Blood
- Normal value 75%
- Range 60-80%
- <60% = cardiac dysfunction
- <35% = severe cardiac dysfunction

P Bauer, K Reinhart, M Bauer. *Significance of venous oximetry in the critically ill.* Med Intensiva. 2008;32(3):134-42. (Department of Anaesthesiology and Critical Care Medicine. Friedrich-Schiller-University. Jena. Germany)

Carbon dioxide ↖ ↙ Oxygen



Adapted from: Smith JJ, Kampine JP. **Circulatory Physiology - the essentials.** 3rd ed.1990. Williams & Wilkins, Baltimore. Chapter 1, page 3.


0
BV▲
-10
-20
-25
HCT 26.9
HGB 9.2
(HCT based est)
TIME 02:00
BV▲-20.9
SAT 49

6 yr.old

Female

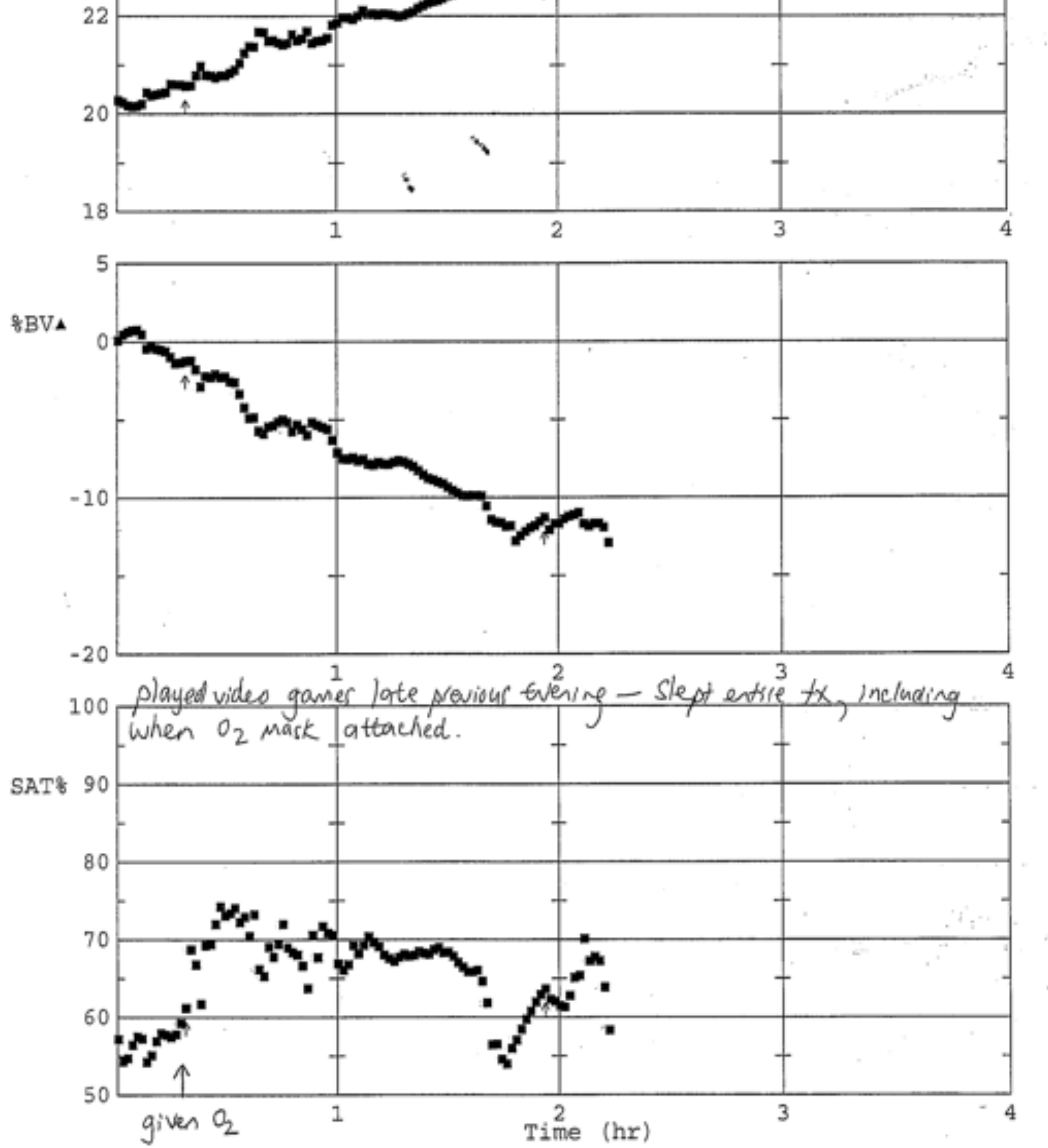
Antibody-mediated anemia

(anti-erythropoeitin antibodies)

Hct (start) 20.3

Hgb (start) 6.8

Sat (min) 53.8



Discuss the dissociation between pressure and volume

OBJECTIVE #6

Volume & Blood Pressure

Hypovolemia

- ↑BP
- ↓BP

Hypervolemia

- ↑BP
- ↓BP

BP = Cardiac Output X Periph Vascular Resist

Sinha AD, Agarwal R: The Pitfalls of the Clinical Examination in Assessing Volume Status. *Seminars in Dialysis-2009* DOI: 10.1111/j/1525-139X/2009/0087641.x

Brewster & Perazella: Cardiorenal Effects of the Renin-Angiotensin-Aldosterone System, *Hospital Physician,* June 2004, pp. 11-20.

Diroll A, Hlebovy D: Inverse relationship between blood volume and blood pressure. Nephrol Nursing J 30:460–461, 2003

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- *West, JB. Respiratory Physiology - the essentials. 3rd Edition. ©1985 Williams & Wilkins. ISBN 0-683-08940-4. Professor of Medicine & Physiology, UC San Diego.*
- *Guyton & Hall, Textbook of Medical Physiology, tenth edition, 2000*
- *Smith & Kampine, Circulatory Physiology -the essentials, third edition, ©1990. ISBN 0-683-07775-9. Prof of Physiology & Medicine, Prof of Anesthesiology & Physiology, Medical College of Wisconsin, Milwaukee.*
- *Brewster & Perazella, Cardiorenal Effects of the Renin-Angiotensin-Aldosterone System. Hospital Physician, June 2004, pp. 11-20. Yale.*
- *Rodriguez,H, Domenici,R, Diroll,A, Goykhman,I: Assessment of DW by monitoring changes in BV during HD using Crit-Line, Kidney International,Vol.68(2005),pp.854-861*
- *Wallis,JP, TRALI, British Journal of Anaesthesia, 2003, Vol. 90, No. 5 573-576*
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- *Daljit K. Hoth,I et al: Pediatric Myocardial Stunning Underscores the Cardiac Toxicity of Conventional Hemodialysis Treatments Clin J Am Soc Nephrol 4: 790 –797, 2009. doi: 10.2215/ CJN.05921108.*
- *Cordtz J et al Central venous oxygen saturation and thoracic admittance during dialysis: New approaches to hemodynamic monitoring. Hemodialysis International 2008; 12:369-377*
- *Hemodynamic monitoring made Incredibly Visual! ©2007 Lippincott Williams & Wilkins.*

The End!

Content

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MA (Kinesiology)

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