importance of an early and correct differential diagnosis.

I	Infections
W	Withdrawal
A	Acute metabolic
T	Trauma
C	CNS pathology
H	Hypoxia
D	Deficiencies
E	Endocrinopathies
A	Acute vascular events
T	Toxins/Drugs
H	Heavy metals

Early diagnosis can be very difficult particularly in intubated and ventilated patients. Sedatives and analgesics can hide the symptoms of delirium. Infection should be monitored by temperature, leucocytes, C-reactive protein or procalcitonin. Acute metabolic disorders or hypoxia and acid base disturbances need to be evaluated by laboratory tests as well as deficiencies, endocrinopathies and intoxications with drugs or other substances.

Primarily cerebral dysfunctions and acute vascular events or trauma must result in differentiated medical imaging (cerebral computed tomography, ultrasound, Doppler sonography).

After exclusion of any other reason the application of special scales to detect and assess delirium or withdrawal syndromes should be performed immediately. There are many different scales for almost every syndrome. In case of alcohol withdrawal the "Revised Clinical Institute of Withdrawal Assessment for Alcohol Scale" (CIWA-Ar) is the state of the art (Spies and Rommelspacher, 1999; Sullivan et al., 1989). In case of opioid withdrawal the modified "Objective Opiate Withdrawal Scale" (OOWS) and "Subjective Opiate Withdrawal Scale" (SOWS) are usually applied in specialized facilities (Handelsman et al., 1987). With these scales alcohol or opiate withdrawal can be documented sufficiently but other conditions leading to delirium are neglected.

Until now, there is no gold standard for monitoring delirium in ICU patients. The ideal scale for assessment and documentation of delirium should be easy to apply and possibly integrated as standardized operating procedure for detecting delirium. Symptoms leading to a differential diagnosis of delirium are very similar to alcohol withdrawal symptoms despite the underlying cause.

The "Delirium Detections Scale" (DDS) (Table 3) is a modified scale from the CIWA-Ar to ICU needs and is composed of five criteria: orientation, hallucination, agitation, anxiety and paroxysmal sweating. It is a validated and reliable measure of the

Table 3   Delirium Detection Score

Item	Description	Scoring
Orientation	• orientated to time, place and personal identity, able to concentrate	0
	• not sure about time and/or place, not able to concentrate	1
	• not orientated to time and/or place	4
	• not orientated to time, place and personal identity	7
Hallucinations	• normal activity	0
	• mild hallucinations at times	1
	• permanent mild-to-moderate-hallucinations	4
	• permanent severe hallucinations	7
Agitation	• normal activity	0
	• slightly higher activity	1
	• moderate restlessness	4
	• severe restlessness	7
Anxiety	• no anxiety when resting	0
	• slight anxiety	1
	• moderate anxiety at times	4
	• acute panic attacks	7
Paroxysmal sweating	• no sweating	0
	• only palms	1
	• beads on the forehead	4
	• severe sweating	7

RASS and CAM-ICU Worksheet

Step One: Sedation Assessment

The Richmond Agitation and Sedation Scale: The RASS*

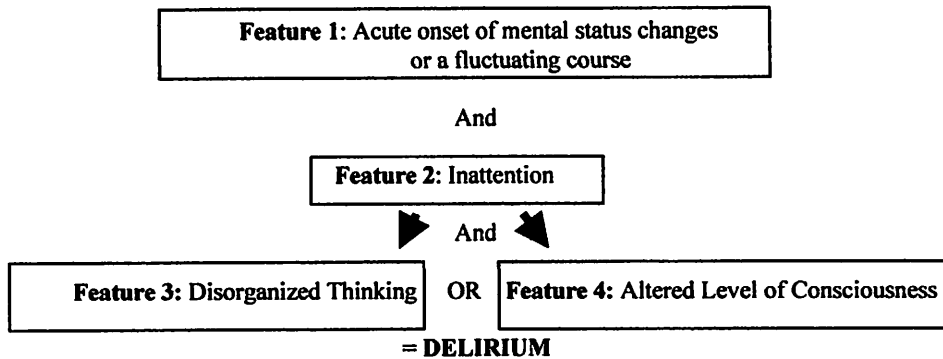| Score	Term	Description	
+4	Combative	Overtly combative, violent, immediate danger to staff	
+3	Very agitated	Pulls or removes tube(s) or catheter(s); aggressive	
+2	Agitated	Frequent non-purposeful movement, fights ventilator	
+1	Restless	Anxious but movements not aggressive vigorous	
0	Alert and calm		
-1	Drowsy	Not fully alert, but has sustained awakening (eye-opening/eye contact) to *voice* (≥10 seconds)	Verbal Stimulation
-2	Light sedation	Briefly awakens with eye contact to *voice* (<10 seconds)	
-3	Moderate sedation	Movement or eye opening to *voice* (**but no eye contact**)	
-4	Deep sedation	No response to voice, but movement or eye opening to *physical* stimulation	Physical Stimulation
-5	Unarousable	No response to *voice or physical* stimulation	

Procedure for RASS Assessment
1. **Observe patient**
   a. Patient is alert, restless, or agitated.   (score 0 to +4)
2. **If not alert, state patient's name and *say* to open eyes and look at speaker.**
   a. Patient awakens with sustained eye opening and eye contact.   (score –1)
   b. Patient awakens with eye opening and eye contact, but not sustained.   (score –2)
      c. Patient has any movement in response to voice but no eye contact.   (score –3)
3. **When no response to verbal stimulation, physically stimulate patient by shaking shoulder and/or rubbing sternum.**
   a. Patient has any movement to physical stimulation.   (score –4)
   b. Patient has no response to any stimulation.   (score –5)

If RASS is -4 or -5, then **Stop** and **Reassess** patient at later time
If RASS is above - 4 (-3 through +4) then **Proceed to Step 2**

*Sessler, et al. AJRCCM 2002; 166:1338-1344. Ely, et al. JAMA 2003; 289:2983-2991.

Step Two: Delirium Assessment

```
┌─────────────────────────────────────────────┐
│  Feature 1: Acute onset of mental status     │
│  changes or a fluctuating course             │
└─────────────────────────────────────────────┘

                    And

        ┌──────────────────────────┐
        │  Feature 2: Inattention  │
        └──────────────────────────┘
                ▶  And  ◀

┌──────────────────────────────────┐     ┌────────────────────────────────────────────┐
│ Feature 3: Disorganized Thinking │ OR  │ Feature 4: Altered Level of Consciousness  │
└──────────────────────────────────┘     └────────────────────────────────────────────┘
```
= **DELIRIUM**

CAM-ICU Worksheet

Feature 1: Acute Onset or Fluctuating Course Positive if you answer 'yes' to either 1A or 1B.	Positive	Negative
1A: Is the pt different than his/her baseline mental status? <center>Or</center> 1B: Has the patient had any fluctuation in mental status in the past 24 hours as evidenced by fluctuation on a sedation scale (e.g. RASS), GCS, or previous delirium assessment?	Yes	No
Feature 2: Inattention Positive if either score for 2A or 2B is less than 8. Attempt the ASE letters first. If pt is able to perform this test and the score is clear, record this score and move to Feature 3. If pt is unable to perform this test or the score is unclear, then perform the ASE Pictures. If you perform both tests, use the ASE Pictures' results to score the Feature.	Positive	Negative
2A: ASE Letters: record score (enter NT for not tested) Directions: Say to the patient, *"I am going to read you a series of 10 letters. Whenever you hear the letter 'A,' indicate by squeezing my hand."* Read letters from the following letter list in a normal tone. <center>S A V E A H A A R T</center>Scoring: Errors are counted when patient fails to squeeze on the letter "A" and when the patient squeezes on any letter other than "A."	Score (out of 10): _____	
2B: ASE Pictures: record score (enter NT for not tested) Directions are included on the picture packets.	Score (out of 10): _____	
Feature 3:Disorganized Thinking Positive if the combined score is less than 4	Positive	Negative
3A: Yes/No Questions (Use either Set A or Set B, alternate on consecutive days if necessary): <center>Set A Set B</center>1. Will a stone float on water? 1. Will a leaf float on water? 2. Are there fish in the sea? 2. Are there elephants in the sea? 3. Does one pound weigh more than 3. Do two pounds weigh two pounds? more than one pound? 4. Can you use a hammer to pound a nail? 4. Can you use a hammer to cut wood? Score ___(Patient earns 1 point for each correct answer out of 4) 3B:Command Say to patient: "Hold up this many fingers" (Examiner holds two fingers in front of patient) "Now do the same thing with the other hand" (Not repeating the number of fingers). *If pt is unable to move both arms, for the second part of the command ask patient "Add one more finger) Score___(Patient earns 1 point if able to successfully complete the entire command)	Combined Score (3A+3B): _____ (out of 5)	
Feature 4: Altered Level of Consciousness Positive if the Actual RASS score is anything other than "0" (zero)	Positive	Negative
Overall CAM-ICU (Features 1 and 2 and either Feature 3 or 4):	Positive	Negative

et al., 2005a). In children a reduction of 10–15% every 6–8 hours following a sedation of less than 5–7 days and a reduction of 10–15% per day in case of long-term sedation for more than 10–14 days has been shown to be safe (Martin et al., 2005a; Tobias, 2000).

The RASS has been recently tested for validity and reliability (Ely et al., 2003). This score comprises ten levels from −5 (unarousable) to +4 (combative).

One of the major advantages of the RASS compared to other scales monitoring sedation is its improved rating of agitated conditions. This facilitates the detection of delirium. If an elevated RASS is recorded it is necessary to specify agitation by one of the scales monitoring delirium (DDS, CAM-ICU) (Fig. 3).

All potential causes for delirium should be considered in the differential diagnosis and be treated as early as possible.
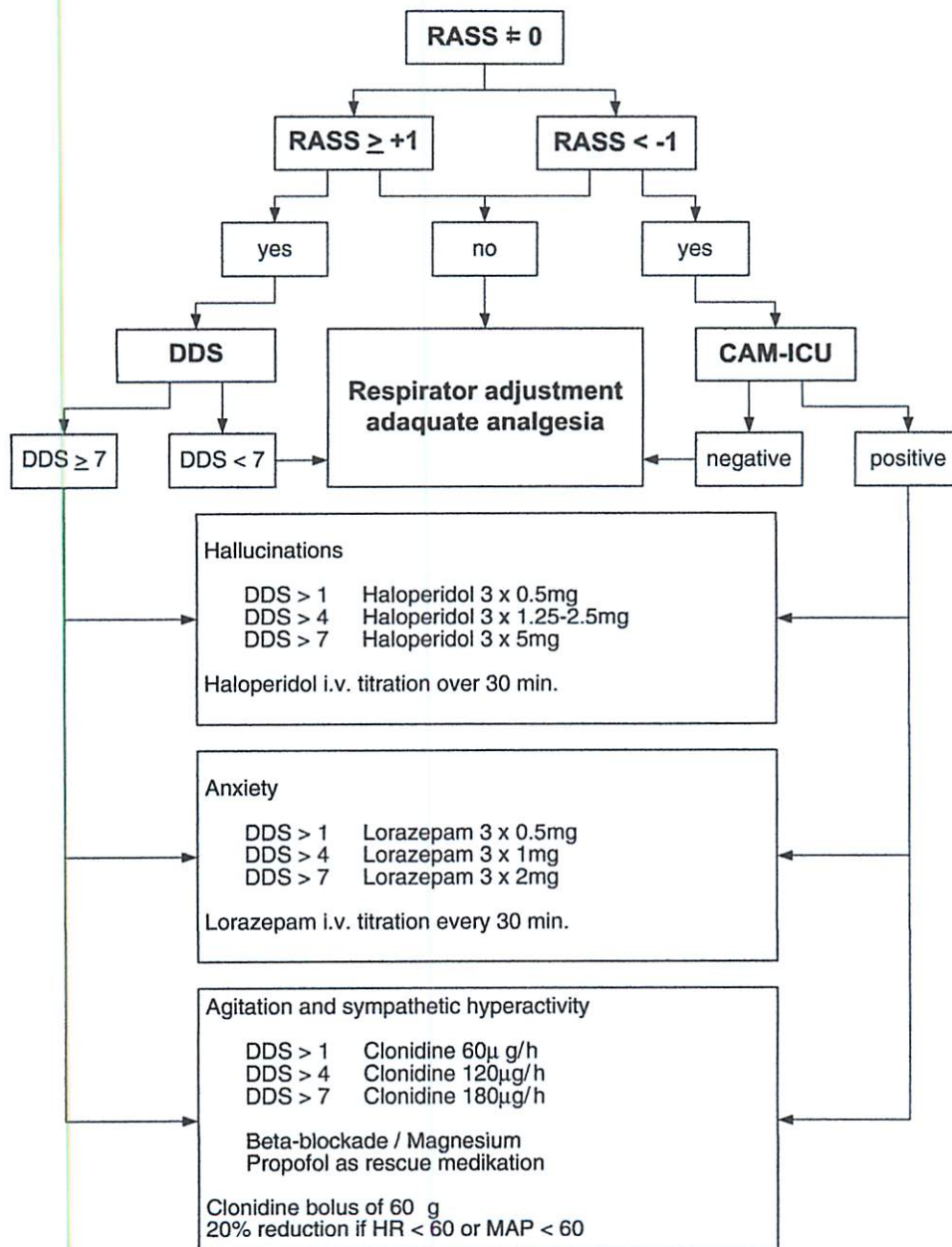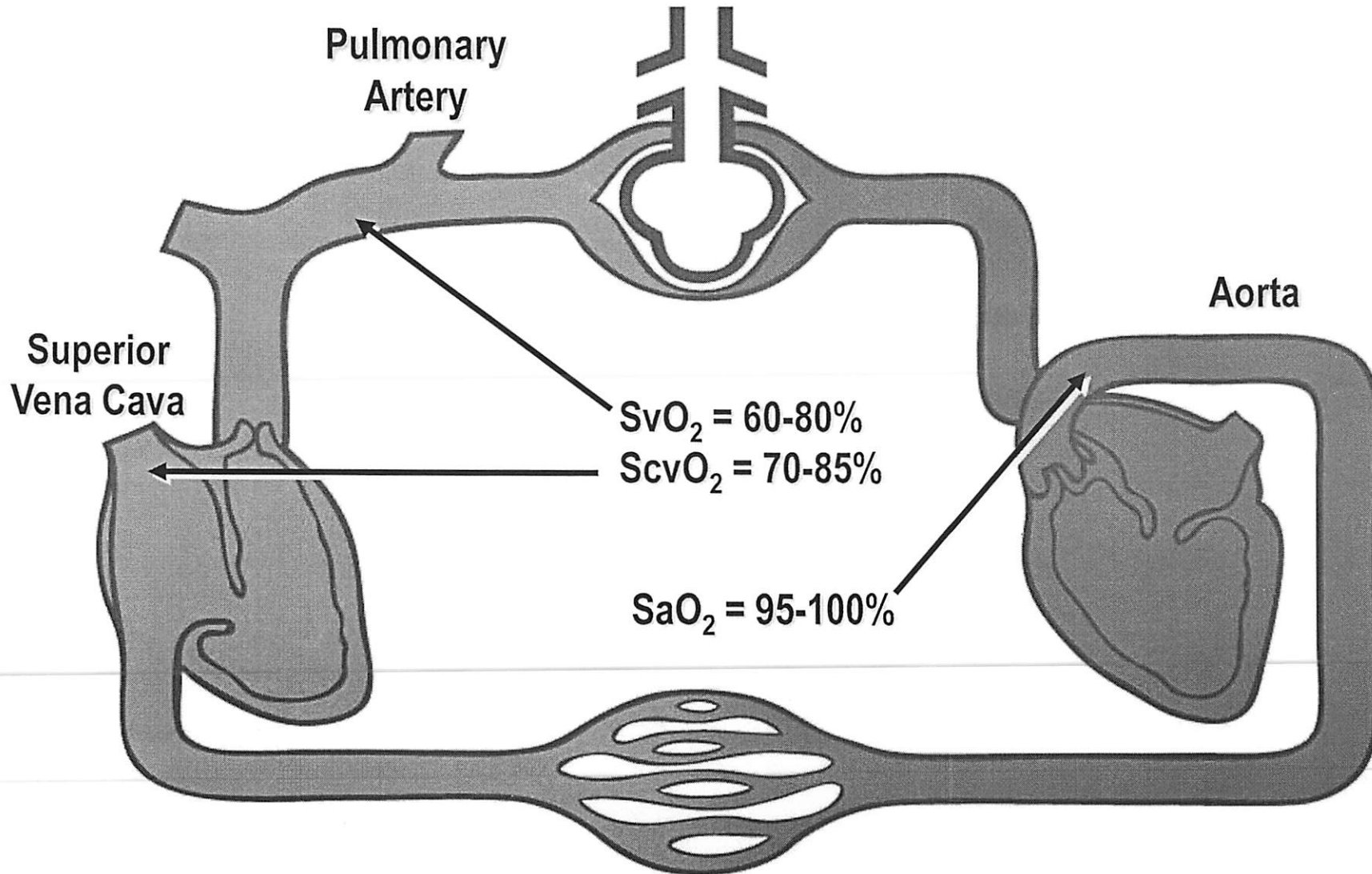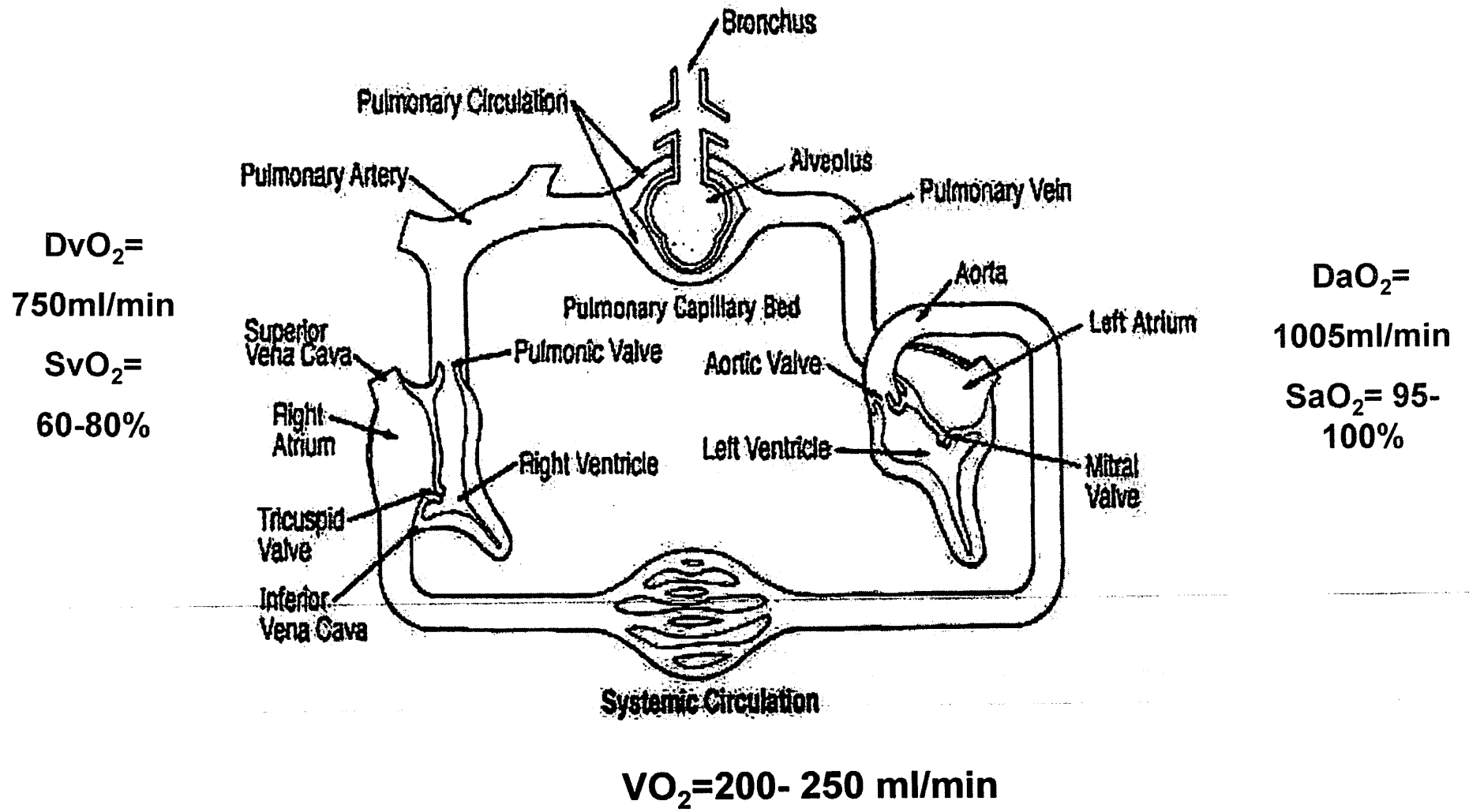

Figure 3 Algorithm for diagnosis and therapy of delirium in critically ill patients. (RASS = Richmond Agitation Sedation Scale; DDS = Delirium Detection Scale; CAM-ICU = Confusion Assessment Method for Intensive Care Unit).

Arterial & Venous Saturations

Pulmonary Artery

Aorta

Superior Vena Cava

$SvO_2 = 60-80\%$
$ScvO_2 = 70-85\%$

$SaO_2 = 95-100\%$

Right & Left Heart Differences

$DvO_2=$ 750ml/min

$SvO_2=$ 60-80%

$DaO_2=$ 1005ml/min

$SaO_2=$ 95-100%

$VO_2=200- 250$ ml/min

Heart Rate

Volume

Resistance

Pump

CO

Bleeding

Hemodilution

Anemia

Hb

$$ScvO_2 / SvO_2$$

SaO$_2$

Oxygenation

FiO2

Ventilation

VO$_2$

Shivering

Fever

Seizures

Muscle Activity

Oxygen Delivery and Consumption

Oxygen Delivery

Hemoglobin

Hemorrhage
Occult bleeding
Anemia
Hemodilution

Cardiac output

Heart rate

Stroke volume

Preload:
CVP

Afterload:
SVR
PVR

Contractility:
SWI

Oxygenation

FiO_2
Ventilation

Oxygen Consumption

VO_2

Fever
Pain
Agitation
Stress/anxiety
Suctioning
Shivering
Trauma
MSOF
Sepsis
Burns

Arterial Oxygen Content

- Oxygen Content = CaO_2

  - Normal Range 17-20 ml/dl

- $CaO2 = (Hb \times 1.38 \times SaO_2) \times (0.0031 \ PaO_2)$

  - Hemoglobin = Hb (carries oxygen molecules)
    - 1.38 : amount of oxygen that can combine with 1 molecule of Hb

  - SaO_2 = % Oxygen saturation in Hemoglobin (This contributes 98% of Oxygen in the arterial blood)

  - PaO_2 = % of Oxygen Dissolved in plasma (This contributes only 2% of total oxygen in the blood)
    - 0.0031 solubility coefficient of oxygen in plasma

Oxygen Consumption

Oxygen Consumption: VO_2

Arterial Oxygen transport – Venous Oxygen Transport

$VO_2 = (CO \times CaO_2) - (CO \times CvO_2)$

$\quad = CO\ (CaO_2 - CvO_2)$

$\quad = CO\ [(SaO_2 \times Hgb \times 13.8) - (SvO_2 \times Hgb \times 13.8)]$

$\quad = CO \times Hgb \times 13.8 \times (SaO_2 - SvO_2)$

$\quad$ Normals : 200 – 250 ml/min

$\qquad\qquad$ 100 – 125 ml/min/m2

Conditions and Activities Altering Demand and VO_2

Fever (one degree C)	10%	Work of Breathing	40%
Shivering	50-100%	Post Op Procedure	7%
ET Suctioning	7-70%	MSOF	20-80%
Sepsis	50-100%	Dressing Change	10%
Visitor	22%	Bath	23%
Position Change	31%	Chest X-Ray	25%
Sling Scale Weighing	36%		

Oxygen Consumption

Clarity in Every Moment

OXYGEN CONSUMPTION
Oxygen Consumption (VO_2) = Oxygen Delivery − Venous Oxygen Return

OXYGEN DELIVERY (DO_2)
[Cardiac output (CO) x
Arterial Oxygen Content (CaO_2)]
(CO) x (1.38 x 15 x SaO_2) + (PaO_2 x .0031)
5 x 20.1 =
NORMAL = 1005 ml O_2/min

VENOUS OXYGEN RETURN
[Cardiac output (CO) x
Venous Oxygen Content (CvO_2)]
(CO) x (1.38 x 15 x SvO_2) + (PvO_2 x .0031)
5 x 15.5 =
NORMAL = 775 ml O_2/min

VO_2 = CO x (CaO_2 − CvO_2) x 10
VO_2 = CO x Hgb x 13.8 x (SaO_2 − SvO_2)
VO_2 = 5 x 15 x 13.8 x (.99 − .75)
NORMAL = 200 − 250ml O_2/min

(handwritten) VO_2 consumption

(handwritten) CvO_2 ที่ออกมา O_2 ที่อยู่ใน 100 ก. ของเลือด vol%

(handwritten) 1.38 ควาก ml of O_2 ที่จับกับ 1 gm ของ Hb

Limits of Mixed Venous Oxygen Saturation

$S\bar{v}O_2 > 75\%$ **Normal Extraction**
Supply > Demand

$75\% > S\bar{v}O_2 > 50\%$ **Compensatory Extraction**
Increasing Demand or
Decreasing Supply

$50\% > S\bar{v}O_2 > 30\%$ **Exhaustion of Extraction**
Beginning of Lactic Acidosis
Demand > Supply

$30\% > S\bar{v}O_2 > 25\%$ **Severe Lactic Acidosis**

$S\bar{v}O_2 < 25\%$ **Cellular Death**

Interpretation ScvO2 /SvO2

- Trend together over 90% of the time

- $ScvO_2$ runs approximately 7% higher than SvO_2

- This difference can widen in shock states

Reinhart K, Kuhn HJ, Hartog C, Bredle DL,
Continuous central venous and pulmonary artery oxygen saturation monitoring in the critically ill.
Intensive Care Med. 2004 Aug

Difference between SvO_2 & $ScvO_2$

- SvO_2 is the "mixed <u>venous</u> blood" oxygen saturation as measured in the pulmonary artery (60-80%)

- SvO_2 is "Mixed Venous blood" because it is blood mixed from the SVC, IVC, and the Coronary Sinus

- $ScvO_2$ is the oxygen saturation as measured in the "<u>central venous circulation</u>" as measured in the Superior Vena Cava (70%)- Upper extremities

Summary

- $ScvO_2$ closely parallels SvO_2 saturation

- In critically ill patients the difference between $ScvO_2$ and SvO_2 varies between 7 – 10% (mean)

- These differences between $ScvO_2$ and SvO_2 saturation result from changes in the regional blood flow and oxygen supply/demand ratio