11 Liberation from invasive mechanical ventilation

11 Liberation from invasive mechanical ventilation

Summary

Use a daily coordinated spontaneous breathing trial (SBT) protocol to liberate patients from mechanical ventilation as soon as possible as this improves patient outcomes!

In patients who fail SBT, recognize and treat reason for failure, and try again the next day. In patients who pass SBT, consider extubation after evaluation of upper airway.

After extubation, monitor the patient over the next 48 hours for signs of respiratory failure and need for prompt re-intubation.

Consider tracheostomy after 10–14 days if prolonged need for mechanical ventilation persists.

Tools

References and resources

American Thoracic Society. Slideshow on ventilator waveforms (https://www.thoracic.org/professionals/clinical-resources/critical-care/clinical-education/mechanical-ventilation/ventilator-waveform-analysis.php (accessed 12 August 2019).

Bice T, Nelson JE, Carson SS. To trach or not to trach: uncertainty in the care of the chronically critically ill. Semin Respir Crit Care Med. 2015;36(6):851–8.

Blackwood B, Alderdice F, Burns KE, Cardwell CR, Lavery G, O'Halloran P. Protocolized versus non-protocolized weaning for reducing the duration of mechanical ventilation in critically ill adult patients. Cochrane Database Syst Rev. 2010;5:CD006904.

Brochard L, Rauss A, Benito S, Conti G, Mancebo J, Rkik N et al. Comparison of three methods of gradual withdrawal from ventilatory support during weaning from mechanical ventilation. Am J Respir Crit Care Med. 1994;150(4):896–903.

Brooks AD, Ahrens TS, Schaiff R, Prentice D, Sherman G, Shannon W et al. Effect of a nursing-implemented sedation protocol on the duration of mechanical ventilation Crit Care Med. 1999;27(12):2609–2615.

Epstein S. Decision to extubate. Intensive Care Med. 2002;28(5):535–546.

Esteban A, Frutos F, Tobin MJ, Alía I, Solsona JF, Vallverdú I et al. A comparison of four methods of weaning patients from mechanical ventilation. Spanish Lung Failure Collaborative Group. N Engl J Med.1995;332(6):345–350.

Esteban A, Alía I, Gordo F, Fernández R, Sonsona JF, Vallverdú I et al. Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation. Spanish Lung Failure Collaborative Group. Am J Respir Crit Care Med. 1997;156(2 Pt 1):459–465.

Fan E, Zakhary B, Amaral A, McCannon J, Girard TD, Morris PE et al. Liberation from mechanical ventilation in critically ill adults. An official ATS/ACCP clinical practice guideline. Ann Am Thorac Soc. 2017;14(3):441–443.

Girard TD, Kress GP, Fuchs BD, Thomason JW, Schweickert WD, Pun BT et al. Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (Awakening and Breathing Controlled trial): a randomised controlled trial. Lancet. 2008;371(9607):126–133.

Klompas M, Anderson D, Trick W, Babcock H, Kerlin MP, Li L et al. The preventability of ventilator-associated events. The CDC Prevention Epicenters Wake Up and Breathe Collaborative. Am J Respir Crit Care Med. 2015;191(3):292–301.

Levine S, Nguyen T, Taylor N, Friscia ME, Budak MT, Rothenberg P et al. Rapid disuse atrophy of diaphragm fibers in mechanically ventilated humans. N Engl J Med. 2008;358(13):1327–1335.

Manthous CA, Schmidt GA, Hall JB. Liberation from mechanical ventilation. Chest.1998:114(3):886–901.

MacIntyre N. Discontinuing mechanical ventilatory support. Chest. 2007;132(3):1049–1056.

MacIntyre NR, Cook DJ, Ely EW Jr, Epstein SK, Fink JB, Heffner JE et al. Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians; the American Association for Respiratory Care; and the American College of Critical Care Medicine. Chest. 2001;120(6 suppl):375S–395S.

Maggiore SM, Idone FA, Vaschetto R, Festa R, Cataldo A, Antonicelli F et al. Nasal high-flow versus Venturi mask oxygen therapy after extubation. Effects on oxygenation, comfort, and clinical outcome. Am J Respir Crit Care Med. 2014;190(3):282–8.

Nilsestuen Jo, Hargett KN. Using ventilator graphics to identify patient-ventilator asynchrony. Respir Care. 2005;50(2):202–234.

Newth CJ, Venkataraman S, Willson DF, Meert KL, Harrison R, Dean JM et al. Weaning and extubation readiness in pediatric patients. Pediatr Crit Care Med. 2009;10(1):1–11.

Rothaar RC, Epstein SK. Extubation failure: magnitude of the problem, impact on outcomes, and prevention. Curr Opin Crit Care. 2003;9(1):59–66.

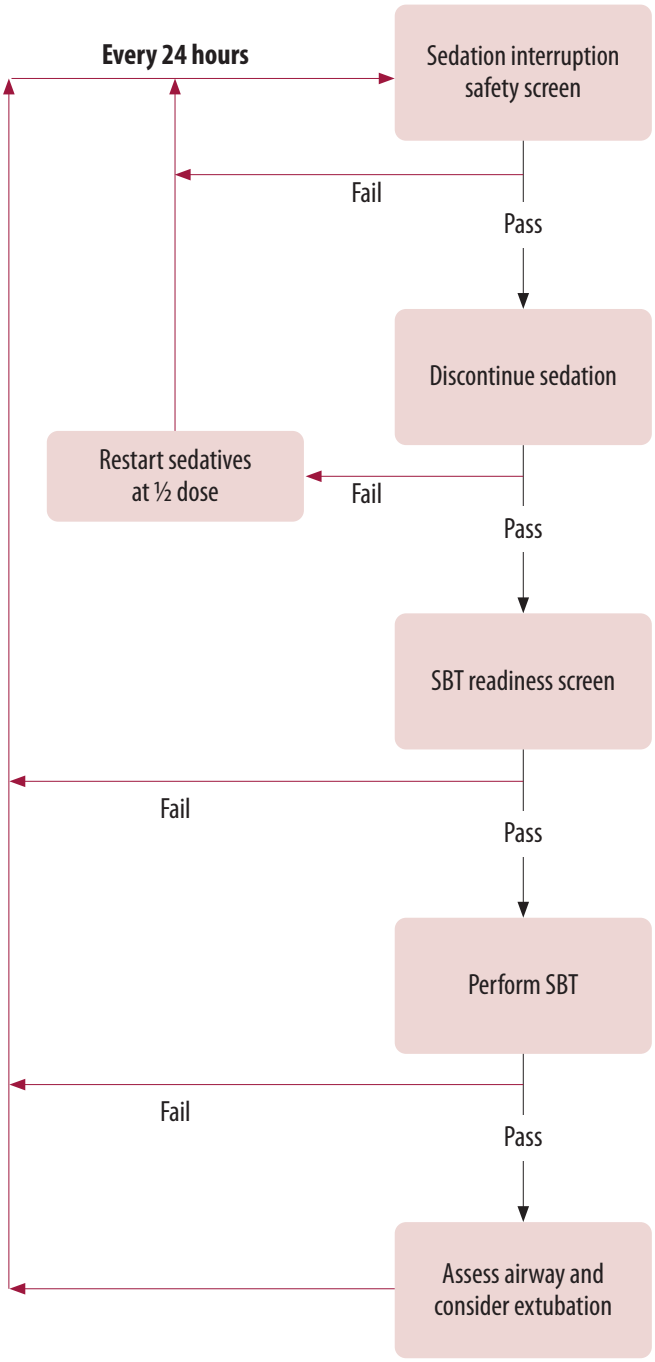
Schmidt GA, Girard TD, Kress JP, Morris PE, Ouellette DR, Alhazzani W et al. Liberation from mechanical ventilation in critically ill adults: executive summary of an official American College of Chest Physicians/ American Thoracic Society Clinical Practice Guideline. Chest. 2017;151(1):160–165.

Siempos II, Ntaidou TK, Filippidis FT, Choi AM. Effect of early versus late or no tracheostomy on mortality and pneumonia of critically ill patients receiving mechanical ventilation: a systematic review and meta-analysis. Lancet Respir Med. 2015;3(2):150–8.

Wittekamp BH, van Mook DH, Zwaveling JH, Bergmans DC. Clinical review: post-extubation laryngenal edema and extubation failure in critically ill adults. Crit Care. 2009;13(6):233.

11.1 Algorithm for coordinating daily sedation interruption with daily SBT

Consider using an algorithmic framework to systematically assess if your patient is ready to have their sedation interrupted and be liberated from the ventilator. This is adapted from the *Awakening and Breathing Controlled trial* (Girard et al, 2008) and can be adapted to your ICU.



Sedation interruption safety screen

- No active seizures
- No alcohol withdrawal
- No agitation
- No neuromuscular blockade
- No myocardial ischemia
- No elevated ICP

Sedation interruption failure

- Anxiety, agitation or pain
- Respiratory rate > 35/min
- SpO_2 < 90%
- Respiratory distress
- Haemodynamic instability

SBT readiness screen

- Spontaneous breathing efforts
- Resolving/stable disease
- SpO_2 ≥ 90% on FiO_2 ≤ 0.50 and PEEP ≤ 8 cm H_2O
- pH > 7.3 and MV ≤ 15 L/min
- No significant vasopressor use[a]
- No myocardial ischemia
- No elevated ICP

SBT failure

Any sign of respiratory failure

- Respiratory rate > 35/min
- Apnea
- SpO_2 < 90%
- Hypoventilation

≥ Two signs of intolerance

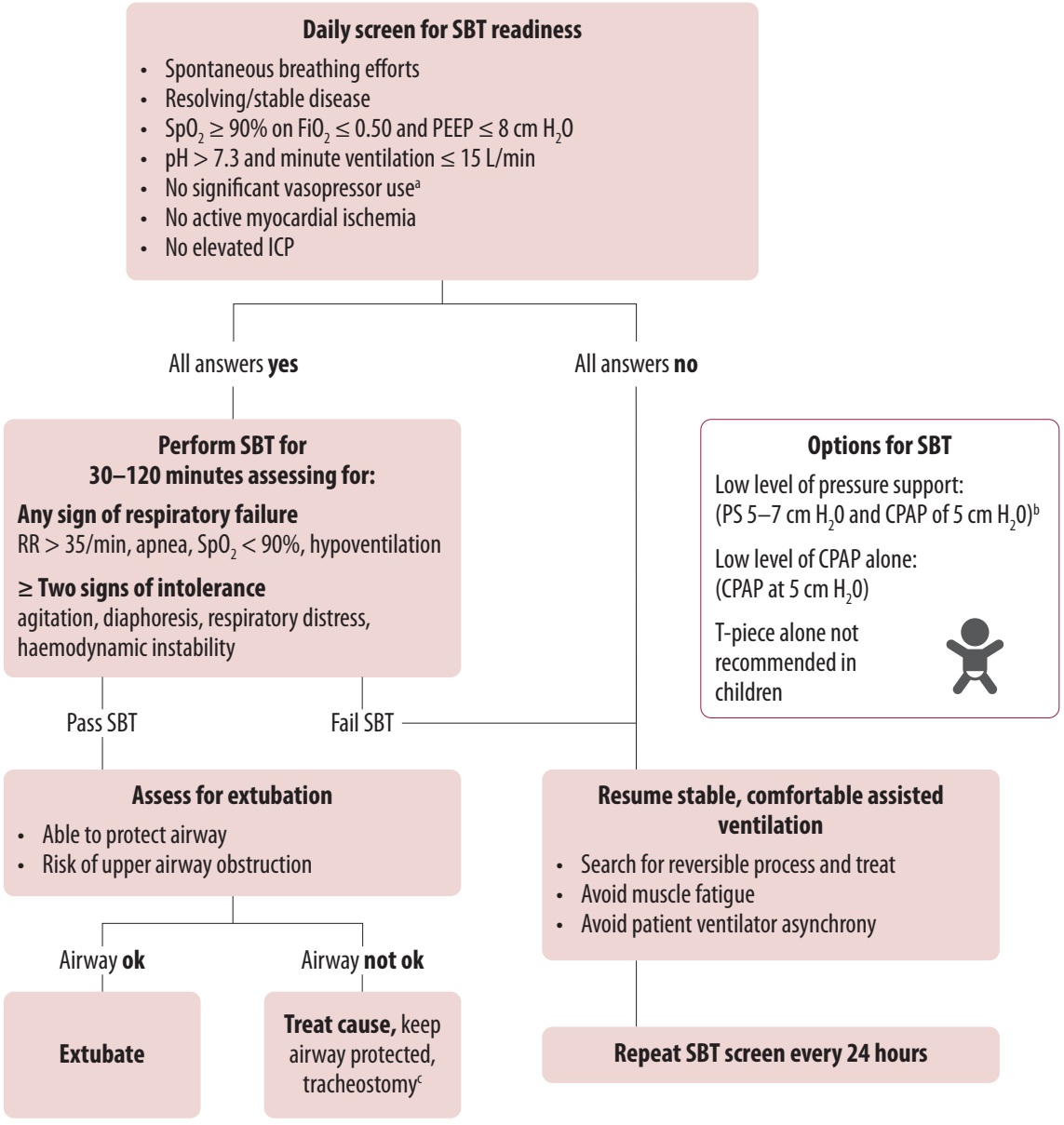
- Agitation
- Diaphoresis
- Accessory muscle
- Haemodynamic instability

Notes:

[a] Dopamine ≤ 5 ug/kg/min or equivalent;
ICP – intracranial pressure; MV – mechanical ventilation.

11.2 Algorithm for liberating patient from invasive mechanical ventilation

Consider using an algorithmic framework to systematically assess if your patient is ready to be liberated from the ventilator. This is adapted from the review article entitled *Discontinuing mechanical ventilatory support* (MacIntyre, 2007).



Notes:

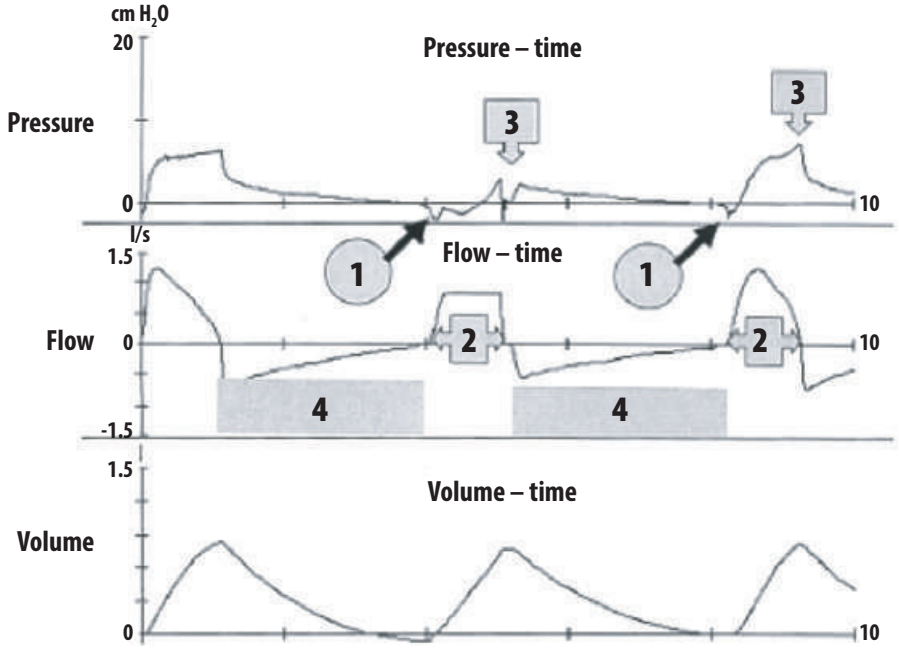
[a] Dopamine ≤ 5 ug/kg/min or equivalent;
[b] PS in children may be higher (10 cm H_2O) given increased resistance in ETT;
[c] Consider tracheostomy based on local practice.

11.3 How to perform a cuff leak test

1. Patient should be sedated or the test done when the patient is asleep to prevent measurement artifacts.
2. Standard vent settings: volume controlled ventilation with TV of 8–10 mL/kg, RR ~10–12, flow rate 50–60 L/min.
3. Suction mouth.
4. Measure the expired TV.
5. Deflate the ETT cuff.
6. Re-measure the expired TV over six breaths:
   - cuff leak is the difference in TV with cuff inflated and deflated;
   - expired TV should decrease by > 100 mL;
   - a value > 130 mL has 85% sensitivity and 95% specificity;
   - reinflate the cuff.

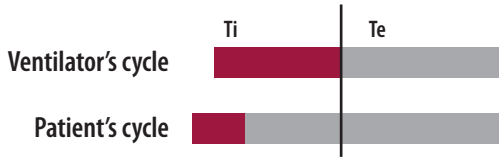
11.4 How to recognize and treat patient–ventilator asynchrony

This is taken from Nilsestuen et al (2005) (see References and resources).

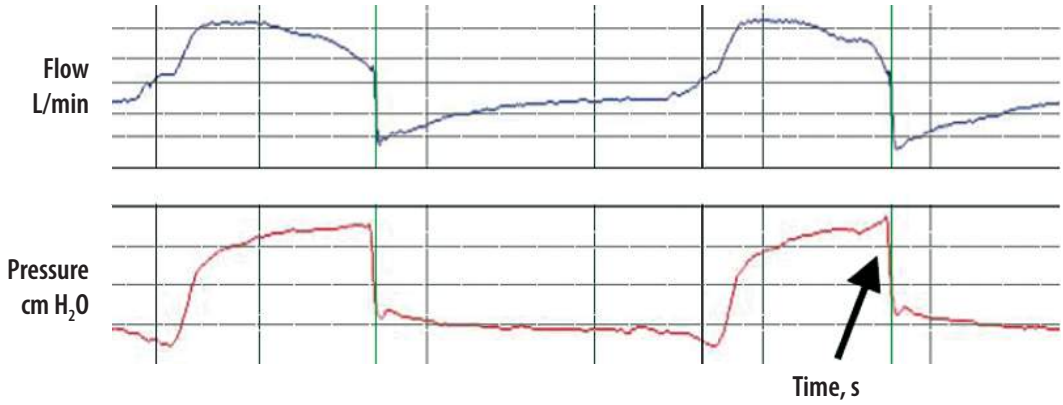


1. Inspiratory triggering
2. Inspiration
3. Termination of inspiration
4. Expiration

Delayed cycling

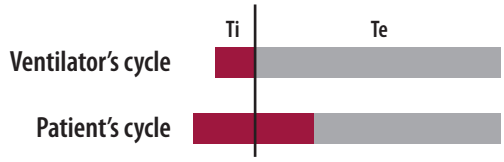


Ventilator inspiratory time is
LONGER
than patient's natural inspiratory time

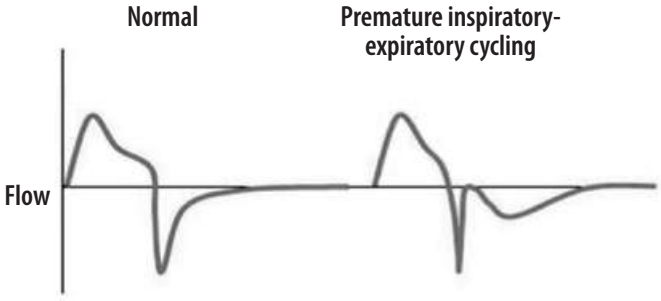


Causes	Interventions
1. Long Ti in controlled modes	Shorten inspiratory time
2. High pressure support in PSV	Decrease pressure support level
3. Auto-PEEP	Treat auto-PEEP
4. Inappropriate rise time	Increase rise time to 40–50%

Premature cycling



Ventilator inspiratory time is SHORTER than patient's natural inspiratory time



Causes	Interventions
1. Short Ti in controlled modes	Prolong inspiratory time
2. Low pressure support in PSV	Increase pressure support level
3. Inappropriate rise time	Reduce rise time to 10%

12 Best practices to prevent complications

12 Best practices to prevent complications

Summary

Key interventions to reduce the risk of complications in the ICU include:

- For patients on invasive mechanical ventilation, perform oral care, semi-recumbent patient position when supine, and appropriate circuit management to prevent ventilator-associated pneumonia (VAP).
- Perform a checklist during all central venous catheter (CVC) insertions to prevent blood stream infection (BSI).
- Give anticoagulants to prevent venous thromboembolism (VTE) for adults and adolescents, unless high risk of bleeding.
- Start early enteral nutrition (EN) to prevent gastric ulcers and infections.
- Conduct early mobilization to prevent ICU-acquired weakness.
- The ABCDE bundle – a set of evidence-based interventions that when coordinated and implemented together can improve patient outcomes.

Tools

References and resources

Arabi YM, Aldawood AS, Haddad SH, Al-Dorzi HM, Tamim HM, Jones G et al. Permissive underfeeding or standard enteral feeding in critically ill adults. N Engl J Med. 2015;372(25):2398–408.

Balas MC, Vasilevskis EE, Olsen KM, Schmid KK, Shostrom V, Cohen MZ et al. Effectiveness and safety of the awakening and breathing coordination, delirium monitoring/management, and early exercise/mobility bundle. Crit Care Med. 2014;42(5):1024–36.

Barnes-Daly MA, Phillips G, Ely EW. Improving hospital survival and reducing brain dysfunction at seven California community hospitals: implementing PAD guidelines via the ABCDEF bundle in 6,064 patients. Crit Care Med. 2017;45(2):171–178.

Brummel NE, Girard TD, Ely EW, Pandharipande PP, Morandi A, Hughes CG et al. Feasibility and safety of early combined cognitive and physical therapy for critically ill medical and surgical patients: the Activity and Cognitive Therapy in ICU (ACT-ICU) trial. Intensive Care Med. 2014;40(3):370–379.

Buendgens L, Bruensing J, Matthes M, Dückers H, Luedde T, Trautwein C et al. Administration of proton pump inhibitors in critically ill medical patients is associated with increased risk of developing Clostridium difficile-associated diarrhea. J Crit Care. 2014;29(4):696.e11–5.

CHECKLIST-ICU Investigators and BRICNet, Machado F, Bozza F, Ibrain J, Salluh F, Campagnucci VP et al. A cluster randomized trial of a multifaceted quality improvement intervention in Brazilian intensive care units: study protocol. Implement Sci. 2015;10:8.

Coffin SE, Klompas M, Classen D, Arias KM, Podgomy K, Anderson DJ et al. Strategies to prevent ventilator-associated pneumonia in acute care hospitals. Infect Control Hosp Epidemiol. 2008;29(suppl 1):S31–40.

Cohen AT, Tapson VF, Bergmann JF, Goldhaber SZ, Kakkar AK, Deslandes B et al. Venous thromboembolism risk and prophylaxis in the acute hospital care setting (ENDORSE study): a multinational cross-sectional study. Lancet. 2008;371(9610):387–94. Erratum in: Lancet. 2008;371(9628):1914.

Geerts WH, Bergqvist D, Pineo GF, Helt JA, Samama CM, Lassen MR et al. Prevention of venous thromboembolism. American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th edition). Chest. 2008;133(suppl 6):381S–453S.

Herridge MS, Tansey CM, Matté A, Tomlinson G, Diaz-Granados N, Cooper A et al. Functional disability 5 years after acute respiratory distress syndrome. N Engl J Med. 2011;7;364(14):1293–304.

IHI. Implement the Central Line Bundle [website resource]. Boston (MA): Institute of Healthcare Improvement; 2019 (http://app.ihi.org/imap/tool/processpdf.aspx?processGUID=e876565d-fd43-42ce-8340-8643b7e675c7, accessed 2 July 2019).

Lo E, Nicolle L, Classen D, Arias KM, Podgomy K, Anderson DJ et al. Strategies to prevent catheter-associated urinary tract infections in acute care hospitals. Infect Control Hosp Epidemiol. 2008;29(suppl 1):S41–S50.

Klompas M, Anderson D, Trick W, Babcock H, Kerlin MP, Li L et al. The preventability of ventilator-associated events. The CDC Prevention Epicenters Wake Up and Breathe Collaborative. Am J Respir Crit Care Med. 2015;191(3):292–301.

MacLaren R, Reynolds PM, Allen RR. Histamine-2 receptor antagonists vs proton pump inhibitors on gastrointestinal tract hemorrhage and infectious complications in the intensive care unit. JAMA Intern Med. 2014;174(4):564–74.

McClave SA, Martindale RG, Varek VW, McCarthy M, Roberts P, Taylor B et al. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient. J Parenter Enteral Nutr. 2009;33(3):277–316.

Muscedere J, Dodek P, Keenan S, Fowler R, Cook D, Heyland D et al. Comprehensive evidence-based clinical practice guidelines for ventilator-associated pneumonia: prevention. J Crit Care. 2008;23(1):126–137.

Pronovost P, Needham D, Berenholtz S, Sinopoli D, Chu H, Cosgrove S et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med. 2006;355:2725–2732.

Schweickert WD, Kress JP. Implementing early mobilization interventions in mechanically ventilated patients in the ICU. Chest. 2011;140(6):1612–1617.

Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, Esbrook CL et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. Lancet. 2009;373(9678):1874–82.

Waters B, Muscedere J. A 2015 update on ventilator-associated pneumonia: new insights on Its prevention, diagnosis, and treatment. Curr Infect Dis Rep. 2015;17(8):496.

WHO. Pocket book of hospital care for children. Guidelines for the management of common illnesses with limited resources (second edition). Geneva: World Health Organization; 2013 (https://www.who.int/maternal_child_adolescent/documents/child_hospital_care/en/, accessed 26 June 2019).

12.1 Checklist for central venous catheter (CVC) insertion

☑ In the literature, a research collaborative found that **using a central line checklist** as a reminder for the inserter **significantly reduced the incidence of central venous catheter-related blood stream infections**. This checklist is adapted from *An intervention to decrease catheter-related blood stream infections in the ICU* (Provonost et al, 2006).

☐ Hand hygiene before the procedure.

☐ Wear maximal barrier precautions on insertion:
- ☐ full sterile gown
- ☐ face mask
- ☐ face shields
- ☐ sterile gloves
- ☐ hair cover
- ☐ cover the patient in a full sterile sheet from head to toe.

☐ Use chlorhexidine 2% in 70% isopropyl alcohol for skin preparation and apply in a back and forth friction rub motion for 30 seconds.

☐ Let dry completely before puncturing site. It should not be blotted dry.

☐ Choose the optimal site: subclavian or internal jugular vein preferred in adults; internal jugular or femoral vein preferred in children depending on age.

☐ Once in place, evaluate the continuing need for the central line on a daily basis.

☐ Remove line immediately when no longer needed or when non-functional.

12.2 Checklist for preventing ventilator-associated pneumonia (VAP)

☑ In order to prevent VAP, a complication of endotracheal intubation and invasive mechanical ventilation, consider the following procedures, when possible:

- ☐ Oral intubation instead of nasal intubation.
- ☐ Keep the patient in a semi-recumbent position (head of bed elevated up to ≥ 30–45°).
- ☐ Use a closed suctioning system.
- ☐ Periodically drain and remove condensation in tubing.
- ☐ Use a new ventilator circuit for each patient. Change if soiled or damaged.
- ☐ Do not routinely change ETT or ventilator circuit, only if malfunctions.
- ☐ Change heat and moisture exchanger when malfunctions, soiled, or every 5–7 days.
- ☐ Perform regular antiseptic oral care with chlorhexidine gel or mouthwash.
- ☐ Discontinue invasive ventilation in a safe and prompt manner:
  - ☐ Daily sedation interruption of continuous sedative infusions.
  - ☐ Daily evaluation for SBT readiness (see Chapter 11).
  - ☐ Extubation to non-invasive ventilation when appropriate (i.e. primarily for patients ventilated because of a COPD exacerbation, and only in centres with sufficient expertise in non-invasive ventilation).
  - ☐ ABCDE bundle.

Note: Heat and moisture exchangers are not routinely used in infants and small children as they significantly increase dead space. Use heated humidifiers instead.

12.3 Checklist for preventing urinary tract infections (UTI)

☑ Prevention of UTI requires an appropriate technique for catheter insertion as well as appropriate management of indwelling catheters. Consider the following procedures when possible:

Catheter insertion

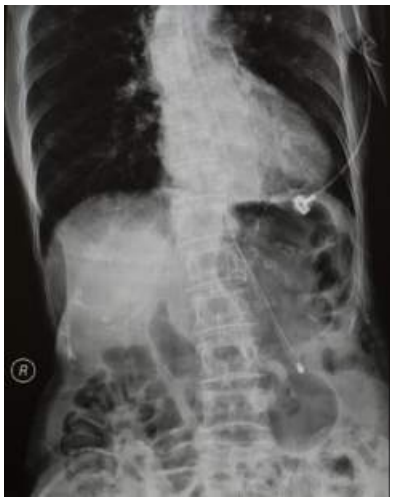
- ☐ Insert catheter only when necessary.
- ☐ Hand hygiene before procedure.
- ☐ Use aseptic technique and sterile equipment.
- ☐ Use as small a catheter as possible, consistent with proper drainage.

Catheter management

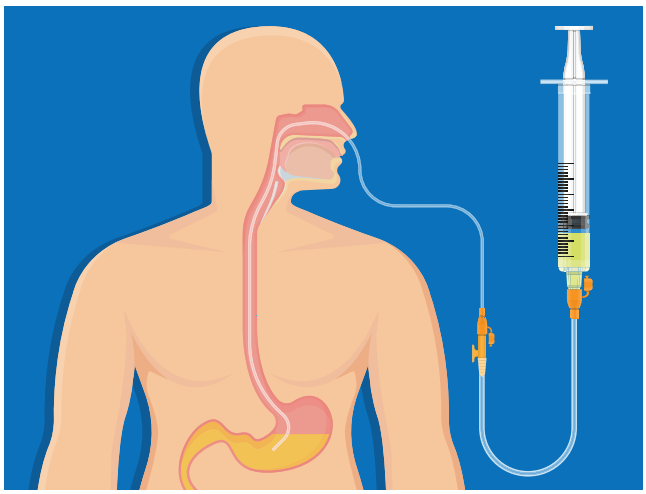
- ☐ Maintain unobstructed urine flow.
- ☐ Empty collection bag regularly:
  - ☐ Separate collecting container for each patient.
  - ☐ Do not allow draining spigot to touch collecting container.
- ☐ Keep collecting bag below level of bladder at all times.
- ☐ Cleaning urethral meatus with antiseptic is unnecessary. Routine cleaning is adequate.
- ☐ Secure catheter to prevent movement and urethral traction.
- ☐ Sterile, continuously closed drainage system.
  - ☐ Do not disconnect catheter and drainage tube unless catheter must be irrigated.
  - ☐ Replace collecting system aseptically and after disinfecting catheter-tubing junction if following occur:
    - break in aseptic technique
    - disconnection
    - leakage.
- ☐ Remove as soon as there is no indication.

12.4 Procedure for providing enteral nutrition (EN) for adults

The goal is to start enteral nutrition, even in small volumes, as soon as the patient is stable. This tool can be used to start enteral nutrition.



1. Place a feeding tube.
2. Confirm placement with radiograph (gastric [NG] or small bowel [NJ] feeding are acceptable).
3. Once the feeding tube has been confirmed, start with an infusion of up to **30 mL/hr of clear fluid or feed**.
4. Aspirate the NG tube every 4 hours.
5. Gradually increase the volume of feed with the aim of building up to full feeding within 48 hours.



Feeding intolerance

Intolerance of feeding may result from poor gastric emptying and lead to high residual gastric volumes.

The absolute value that is too high and should prompt cessation of tube feeds is not clear.

Stop feeding when:
- volumes high (between 250–500 mL)
- clinical signs of intolerance (abdominal pain, abdominal distension and diarrhoea).

None of the features are specific for feed intolerance.

Possible treatments include advancing the feeding tube into the small bowel (can be done at the bedside) or adding prokinetic medications (e.g. metoclopromide intravenously).

Note: With an NJ tube, only continuous feeds can be delivered (no bolus) and residuals cannot be checked.

Set caloric target and aim to reach this within a few days

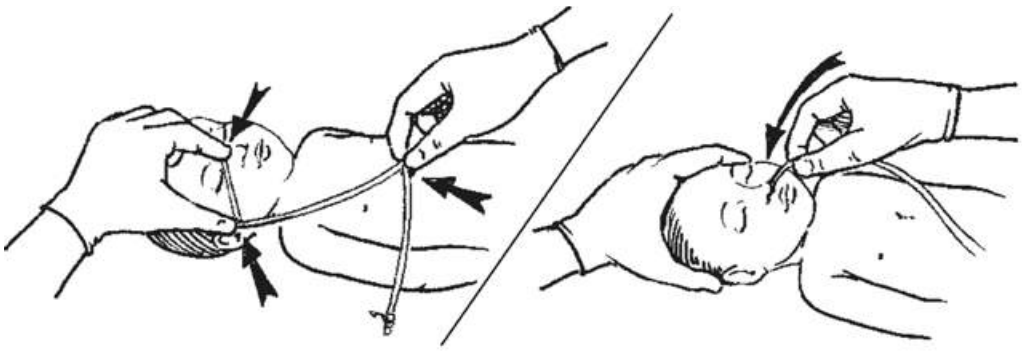
Estimate the patient's daily caloric needs, or basal energy expenditure (BEE). Adjust for fever and stress:
- BEE (kcal/day) = 25 × body weight (kg)
- fever: BEE × 1.1 (for each degree above the normal body temperature)
- mild to moderate stress: BEE × 1.2–1.4
- moderate to severe stress: BEE × 1.4–1.6.

Estimate your patient's daily protein requirements:
- normal 1.2– 2.0 g/kg
- hypercatabolism: 2–3 g/kg
- ratio of non-protein calories to nitrogen (70:1–100:1).

Note: Hypocaloric feeding (40–60% of non-protein caloric needs) may be as beneficial as full caloric feeds (> 70%).

12.5 Procedure for providing enteral nutrition (EN): paediatric considerations

Enteral feeding via NG tube is the preferred method of providing maintenance fluid.



Source: Pocket book of hospital care for children (WHO, 2013).

Initial fitting

1. Measure the distance from the nose to the ear and then to the epigastrium.
2. Insert NG tube to the measured distance.
3. Check correct placement of tube:
   - check the pH of aspirate using pH indicator strips
   - position can be seen on chest X-ray
   - if in doubt remove and replace.
4. Secure the NG tube by taping to the cheek avoiding upwards pressure on the nares.
5. Once correct placement has been confirmed, flush the tube with water. It is now safe to use the tube for administration of feed and medication.
6. Flush the NG tube with sterile water after administration of NG drugs otherwise it will block.

Ongoing checks

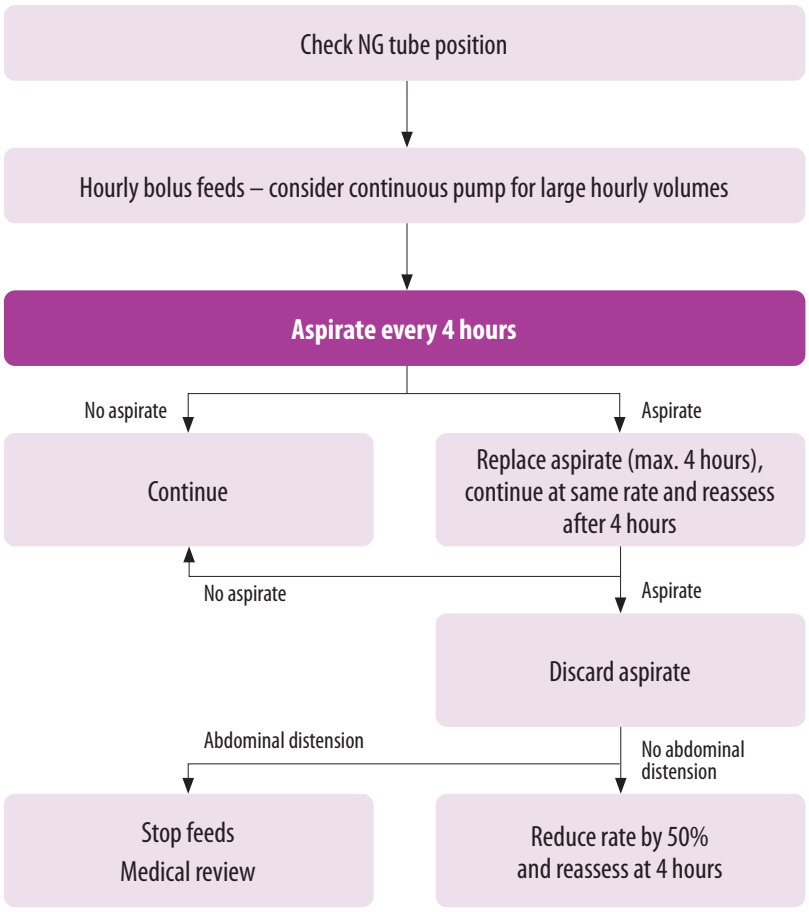
Check the position of the NG tube:

- before each use
- every 6 hours if continuous feeds
- after episodes of vomiting or retching, increased respiratory distress or excessive coughing
- if the tube looks dislodged (i.e. with more tubing visible).

NG tube sizes

This is only a rough guide; the bore of tube must fit easily in the child's nostril.

Description of patient	Tubes sizes
< 2 kg, preterm	4 Fr
2–4 kg	6 Fr
Term to 1 year	8 Fr
Younger children	10 Fr
Older children and adolescents	12 Fr
Small adult	14 Fr
Large adult	16 Fr

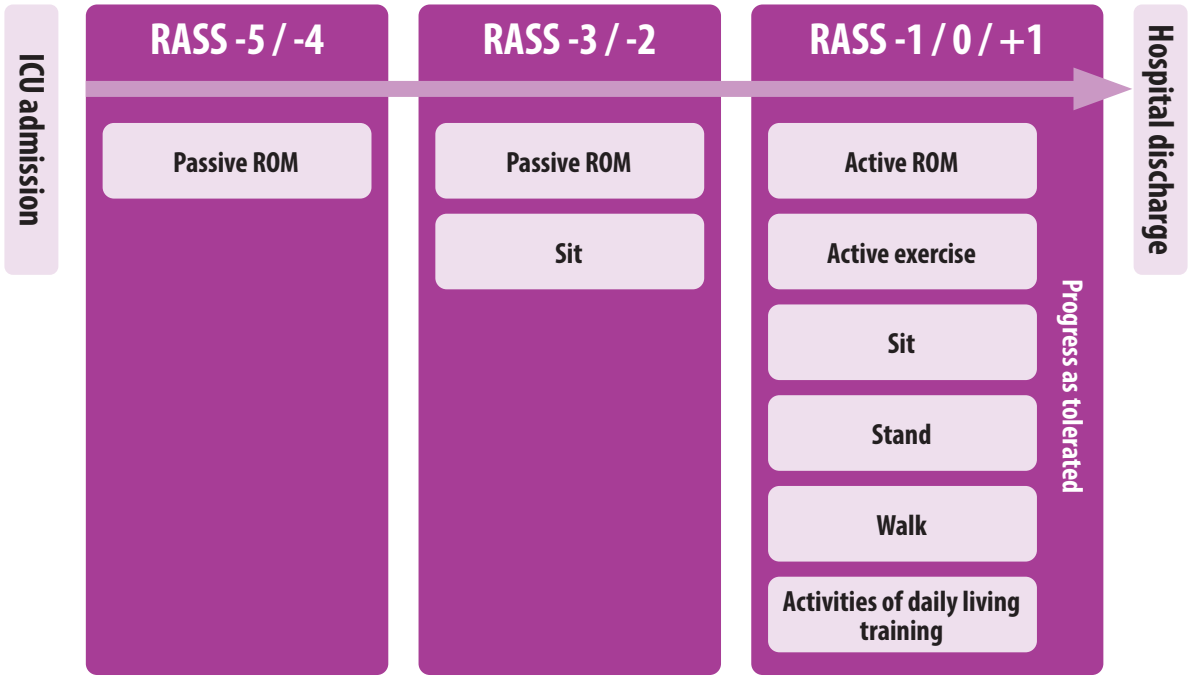

Check NG tube position
Hourly bolus feeds – consider continuous pump for large hourly volumes
Aspirate every 4 hours
No aspirate
Aspirate
Continue
Replace aspirate (max. 4 hours), continue at same rate and reassess after 4 hours
No aspirate
Aspirate
Discard aspirate
Abdominal distension
No abdominal distension
Stop feeds
Medical review
Reduce rate by 50% and reassess at 4 hours

12.6 Algorithm for early mobility in the ICU

An adapted early mobility algorithm is presented below. It is adapted from Balas et al (2014).

The patient's level of consciousness will be determined prior to the daily physical rehabilitation session using the Richmond Agitation-Sedation Scale. A patient who is only arousable to physical stimulation (RASS -4/-5) will undergo passive range of motion (ROM) exercises. Once a patient can open their eyes to voice (RASS -2/-3), passive ROM exercises will be performed, and the patient will be placed in the chair position in bed. Finally, once a patient is alert and calm, they will progress from active ROM up through ambulation as they are able. Sessions will continue until hospital discharge or a patient meets certain functional milestones.

Physical rehabilitation protocol

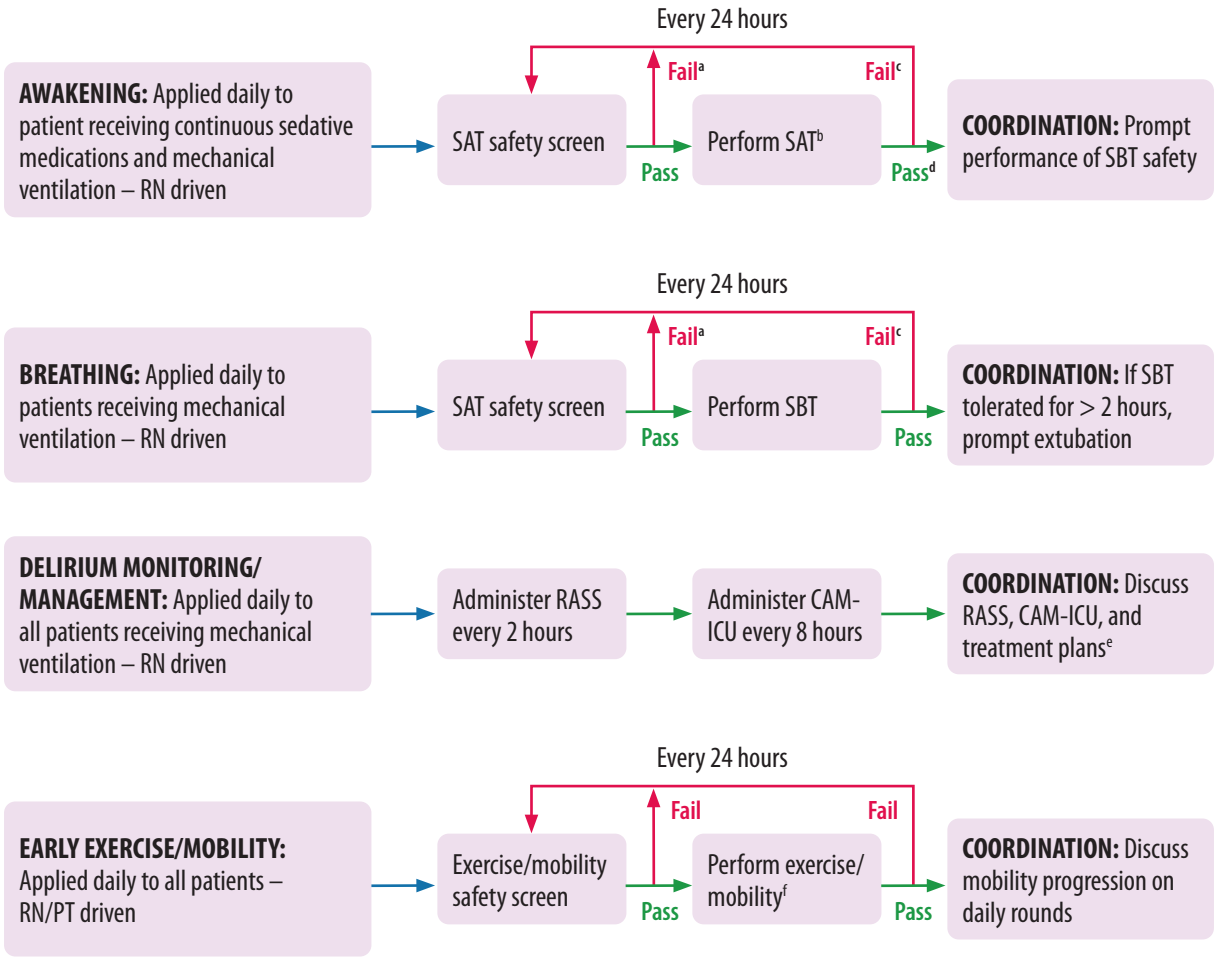


12.7 ABCDE bundle

This algorithm is adapted from Balas et al (2014) (see References and resources). Implementing this bundle reduced the number of days patients spent on invasive mechanical ventilation by 3. Additionally, patients experienced less delirium and were more likely to be mobilized.

Adapt this bundle to fit your ICU and implement using a quality improvement mechanism.

ABCDE bundle algorithm



Notes:

[a] Continuous sedative medications maintained at previous rate if spontaneous awakening trail (SAT) safety screen failure. Mechanical ventilation continued, and continuous sedative medications restarted at half the previous dose only if needed due to SBT safety screen failure.

[b] Continuous sedative infusions stopped, and sedative boluses held. Bolus doses of opioid medications allowed for pain. Continuous opioid infusions maintained only if needed for active pain.

[c] Continuous sedative medications restarted at half the previous dose, and then titrated to sedation target if SAT failed. Interdisciplinary team determines possible causes of SAT/SBT failure during rounds. Mechanical ventilation restarted at previous settings, and continuous sedative medications restarted at half the previous dose only if needed if SBT failed.

[d] SAT pass if the patient can open their eyes to verbal stimulation without failure criteria (regardless of trial length) or does not display any of the failure criteria after 4 hours of shutting off sedation.

[e] Each day on interdisciplinary rounds, the RN will inform the team of the patient's target RASS score, actual RASS score, CAM-ICU status, and sedative and analgesic medications the patients is receiving. If delirium is detected, team will discuss possible causes, eliminate risk factors, and employ non-pharmacologic management strategies.

[f] Each eligible patient is encouraged to be mobile at least once a day, with the specific level of activity geared to their readiness. Patients progress through a three-step process, embarking on the highest level of physical activity they can tolerate. Progress includes sitting on edge of bed, standing at bedside and sitting in chair, and walking a short distance. Use of the protocol ends when the patient is discharged from the ICU.

CAM-ICU = confusion assessment method for the intensive care unit; PT – physical therapist; RASS – Richmond Agitation-Sedation Scale; RN – registered nurse; RT – respiratory therapist; SAT – spontaneous awakening trial; SBT – spontaneous breathing trial.

ABCDE bundle safety screen questions and success/fail criteria

ABCDE bundle component	Safety screen criteria: conditions for exclusion	Pass/fail criteria: conditions denoting failure
Spontaneous awakening trial	1. Active seizures 2. Alcohol withdrawal 3. Neuromuscular blockade 4. Control of increased ICP 5. ICP > 20 mmHg 6. Receiving ECMO 7. Documentation of MI in past 24 hours 8. Current RASS > 2	1. RASS score > 2 for ≥ 5 minutes 2. Pulse oximetry < 88% for ≥ 5 minutes 3. Respirations > 35 BPM for ≥ 5 minutes 4. Acute cardiac arrhythmia 5. ICP > 20 mmHg 6. Two or more of the following: (heart rate increase ≥ 20 BPM, heart rate < 55 BPM, use of accessory muscles, abdominal paradox, diaphoresis or dyspnea)
Spontaneous breathing trial	1. Chronic ventilator dependence 2. Pulse oximeter reading < 88% 3. FiO_2 > 50% 4. Set PEEP > 7 5. ICP > 20 mmHg 6. Receiving mechanical ventilation in attempt to control ICP 7. Documentation of MI in past 24 hours 8. Increasing doses of vasopressor medications 9. Lack of inspiratory effort	1. RR > 35 BPM for ≥ 5 minutes 2. RR < 8 3. Pulse oximetry < 88% > 5 minutes 4. ICP > 20 mmHg 5. Mental status changes 6. Acute cardiac arrhythmia 7. Two or more of the following: • use of accessory muscles • abdominal paradox diaphoresis • dyspnea
Early exercise/ mobility	1. RASS < −3 2. FiO_2 > 0.6 3. Set PEEP > 10 cm H_20 4. Increasing doses of vasopressor infusions in the last 2 hours 5. Evidence of active MI 6. Administration of a new antiarrhythmic agent 7. Receiving therapies that restricted mobility (e.g. ECMO, open-abdomen, etc.) 8. Injuries in which mobility is contraindicated (e.g. unstable fractures, etc.)	1. Symptomatic drop in mean arterial pressure 2. Heart rate < 50 or > 130 BPM ≥ 5 minutes 3. RR < 5 or > 40 BPM ≥ 5 minutes 4. Systolic blood pressure > 180 mmHg ≥ 5 minutes 5. Pulse oximetry < 88% ≥ 5 minutes 6. Marked ventilator dyssynchrony 7. Patient distress 8. New arrhythmia or evidence of active MI 9. Concern for airway device integrity or endotracheal removal 10. Fall to knees

Notes: ABCDE – Awakening and Breathing Coordination, Delirium Monitoring/Management and Early Mobility Bundle; BPM – beats per minute; ECMO – extracorporeal membrane oxygenation; FiO_2 – fraction of inspired oxygen; ICP – intracranial pressure; MI – myocardial ischemia; PEEP – positive end-expiratory pressure; RASS – Richmond Agitation-Sedation Scale; RR – respiratory rate.

Bedside checklist for ABCDE protocol

Date:_____/_____/_____

A B C Awakening and Breathing Coordination

	Check if yes or indicate reasons
SAT screen passed? If not, why?	
SAT done? If not, why?	
SBT screened passed? If not, why?	
SBT done? If not, why?	
SAT and SBT coordinated/paired?	

D Delirium nonpharmacologic interventions

Intervention	Check if done
Pain assessment/management	
Orientation	
Sensory (eyes/ears)	
Sleep (nonpharm)	
Check any intervention that was performed during your shift (including night shift)	

E Early Exercise and mobility

Intervention	Check if done
Active ROM	
Sitting up on side of bed	
Standing	
Walking	
Check any level of activity the patient performed during your shift (including night shift)	

Notes: ROM – range of motion; SAT – spontaneous awakening trial; SBT – spontaneous breathing trial.

13 Quality in critical care

13 Quality in critical care

Summary

Quality is the provision of safe, timely, effective, efficient, equitable, and patient-centred care.

Systematic and continuous quality improvement work is essential because health care delivery is complex and imperfect, even with the best efforts.

Quality measures are related to ICU resources/structure, processes of care and patient outcomes. The focus should be on processes of care, instead of hard-to-measure outcomes.

Use the iterative, real-time, **plan-do-act-check** cycle to test changes/improvement.

Create an inclusive team and culture of change for a successful and sustainable quality improvement programme.

Tools

References and resources

AHQR. Quality measure tools and resources [website]. Rockville (MD): Agency for Healthcare Research and Quality (http://www.ahrq.gov/professionals/quality-patient-safety/quality-resources/index.html, accessed 3 July 2019).

Bion JF, Heffner JE. Challenges in the care of the acutely ill. Lancet. 2004;363(9413):970–977.

Brown L, Franco LM, Rafeh N, Hatzell T. Quality assurance of health care in developing countries. Quality Assurance Methodology Refinement Series. Bethesda (MD): Quality Assurance Project; 2000.

Campbell H, Duke T, Weber M, English M, Carai S, Tamburlini G et al. Global initiatives for improving hospital care for children: state of the art and future prospects. Pediatrics. 2008;121(4):e984–994.

Curtis JR, Cook DJ, Wall RJ, Angus DC, Bion J, Kacmarek R et al. Intensive care unit quality improvement: a "how-to" guide for the interdisciplinary team. Crit Care Med. 2006;34(1):211–8.

Hales BM, Pronovost P. The checklist – a tool for error management and performance improvement. J Crit Care. 2006;21(3):231–235.

Hales BM, Terblanche M, Fowler R, Sibbald W. Development of medical checklists for improved quality of patient care. Int J Qual Health Care. 2008;20(1):22–30.

HMD. Health and Medicines Division, National Academies of Sciences, Engineering and Medicine, United States of America [website]. Washington (DC) (http://www.nationalacademies.org/hmd/, accessed 12 August 2019).

IHI. How to improve [website]. Boston (MA): Institute for Healthcare Improvement; 2019 (http://www.ihi.org/resources/Pages/HowtoImprove/ScienceofImprovementSettingAims.aspx, accessed 3 July 2019).

Kuzniewicz MW, Vasilevskis EE, Lane R, Dean ML, Trivedi NG, Rennie DJ et al. Variation in ICU risk-adjusted mortality impact of methods of assessment and potential confounders. Chest. 2008;133(6):1319–1327.

Langley GL, Moen RD, Nolan KM, Nolan TW, Norman CL, Provost LP. The improvement guide: a practical approach to enhancing organizational performance (2nd edition). San Francisco (CA): Jossey-Bass Publishers; 2009.

Murthy S, Wunsch H. Clinical review: international comparisons in critical care – lessons learned. Crit Care. 2012;16(2):218. doi: 10.1186/cc11140.

WHO. Assessing and tackling patient harm: a methodological guide for data-poor hospitals. Geneva: World Health Organization; 2010 (https://apps.who.int/iris/handle/10665/77100, accessed 3 July 2019).

13.1 Checklist for daily best practices

☑ Consider using this checklist to assess if your patient is receiving appropriate preventative interventions.

Patient: . . . . . **Date:** . . . . .

Light sedation target

- ☐ Yes
- ☐ Not a candidate, why?

. . . . . .

Spontaneous breathing trials

- ☐ Yes
- ☐ Not a candidate, why?

. . . . . .

Head of bed elevation

- ☐ Yes
- ☐ Not a candidate, why?

. . . . . .

Skin breakdown assessment

- ☐ Yes
- ☐ Not done, why?

. . . . . .

Enteral nutrition

- ☐ Yes
- ☐ Not a candidate, why?

. . . . . .

Deep venous thrombosis prophylaxis

- ☐ Yes
- ☐ Not a candidate, why?

. . . . . .

Gastric ulcer prophylaxis

- ☐ Yes
- ☐ Not a candidate, why?

. . . . . .

Antibiotics

- ☐ Yes
  (day . . . . . of . . . . .)
- ☐ No

Early mobility

- ☐ Yes
- ☐ No, why?

. . . . . .

Needs Foley catheter

- ☐ Yes
- ☐ No

Needs central venous catheter

- ☐ Yes
- ☐ No

Source: Adapted with permission from San Francisco General Hospital, San Francisco (CA).

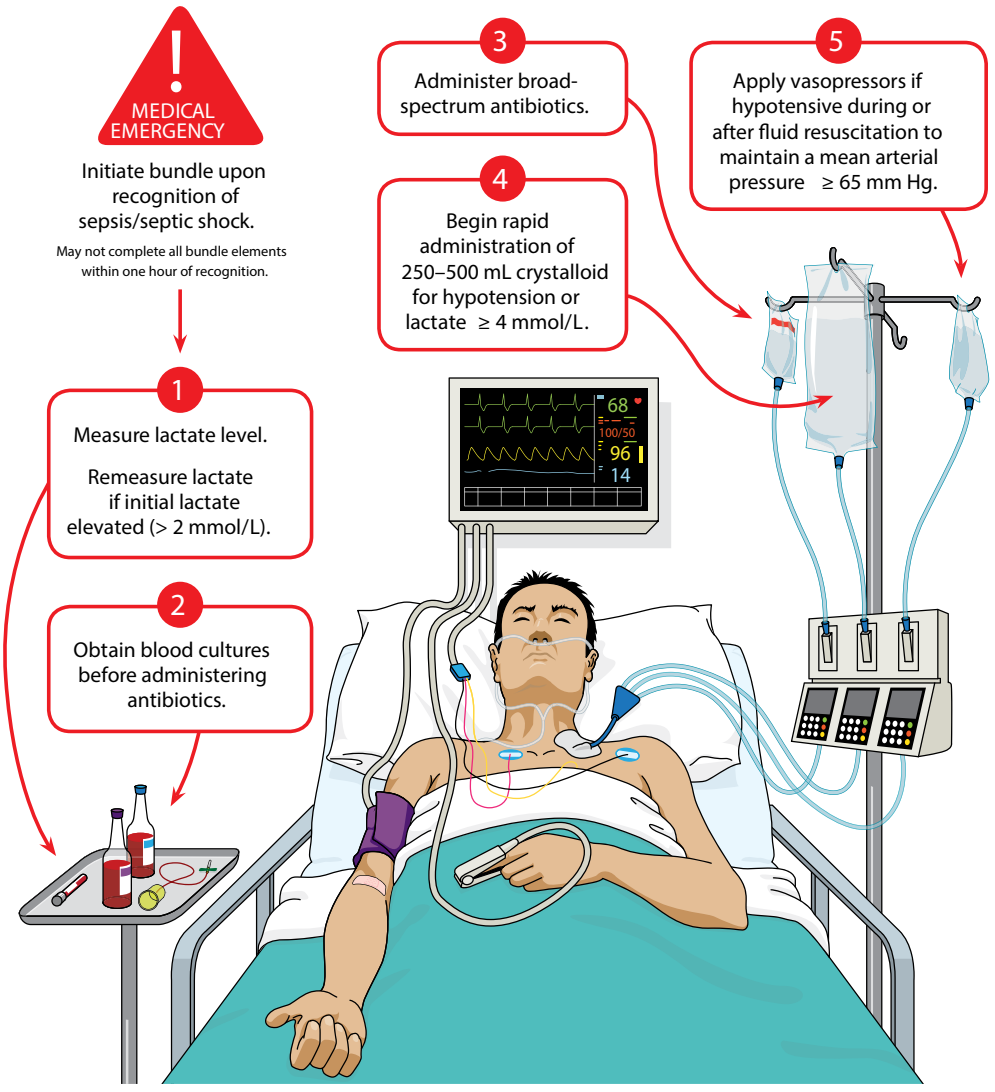
13.2 Surviving Sepsis Campaign bundles

Consider using an adapted version of this tool to monitor performance for sepsis care. This bundle was recently revised based on the most recent version of these tools. See the Surviving Sepsis Campaign website for full details (https://www.sccm.org/getattachment/SurvivingSepsisCampaign/Guidelines/Adult-Patients/Surviving-Sepsis-Campaign-Hour-1-Bundle.pdf?lang=en-US).

The Paediatric Surviving Sepsis Campaign Bundle can be found in Chapter 8 (Tool 8.3) or on the Surviving Sepsis website (https://www.sccm.org/getattachment/SurvivingSepsisCampaign/Guidelines/Pediatric-Patients/Initial-Resuscitation-Algorithm-for-Children.pdf?lang=en-US).

Hour-1 bundle: initiate bundle upon recognition of sepsis/septic shock

May not complete all elements within first hour.



Remember

1. Act quickly upon sepsis and septic shock recognition; 2. Minimize time to treatment – sepsis and septic shock are medical emergencies; 3. Monitor closely for response to interventions; 4. Communicate sepsis status in hand-offs.

13.3 Checklist: high-quality use of invasive mechanical ventilation for ARDS

☑ Consider using this tool if you are using IMV to deliver quality care to your patients with ARDS.

Technical competence

- ☐ Type of mechanical ventilator available.
- ☐ Able to deliver PEEP.
- ☐ Able to measure plateau airway pressure.
- ☐ Able to deliver high concentrations of oxygen.
- ☐ Intubation equipment readily available.
- ☐ Infection prevention materials readily available (airborne precautions).
- ☐ Skilled person to intubate available.
- ☐ Skilled personnel to use and troubleshoot IMV.
- ☐ Arterial blood gas analyser available and working.
- ☐ Pulse oximeter available and working.

Safety

- ☐ Plan for difficult airway (e.g. backup personnel, equipment, and plan – e.g. cricothyrotomy).
- ☐ Plan for IMV complications (e.g. chest tube for pneumothorax, sedation for agitation).
- ☐ Plan for prevention while on IMV (e.g. daily SBT evaluation, daily sedation interruption, VAP prevention).

Process measures

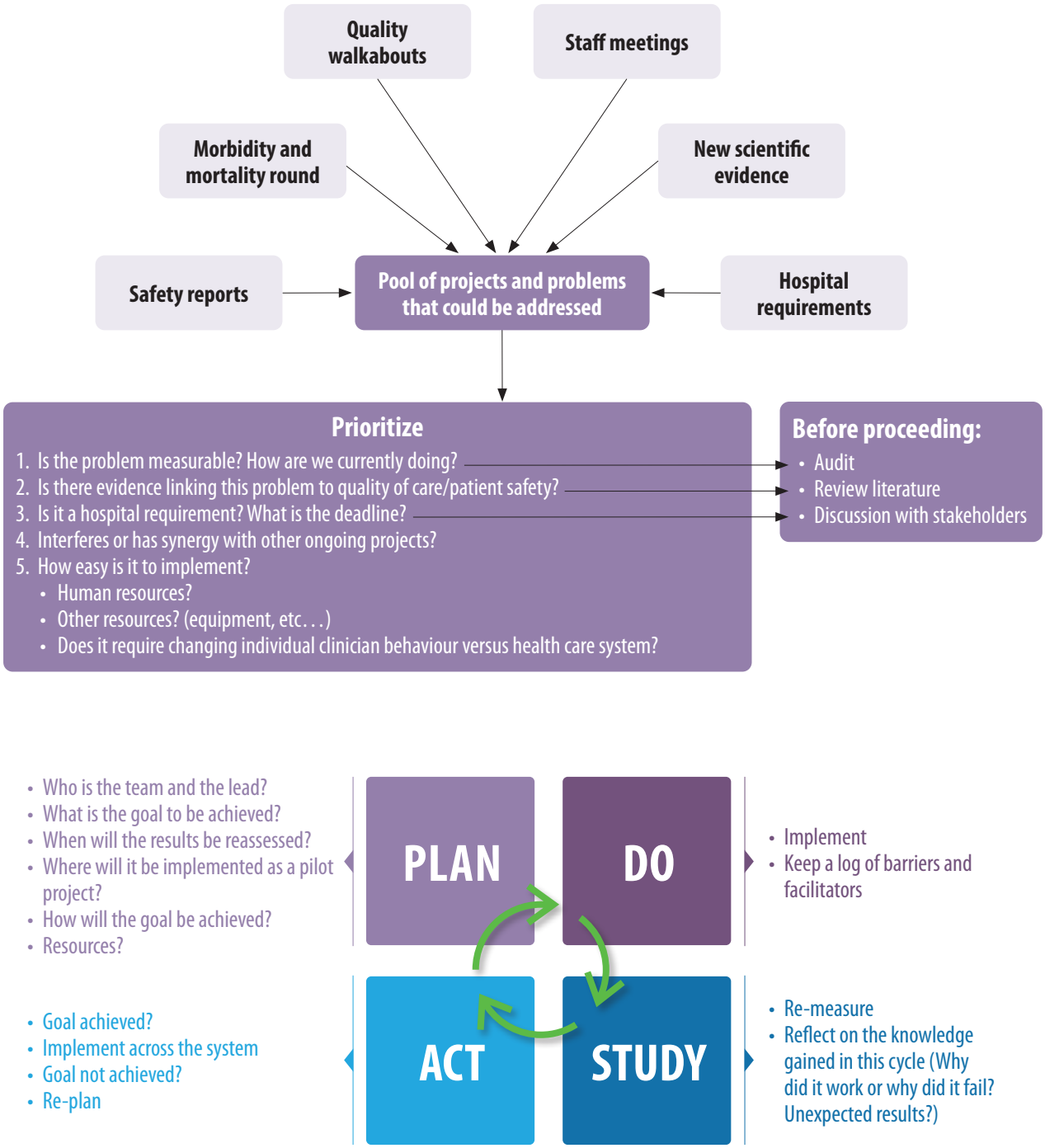
- ☐ Process measures (e.g. lung protective targets met).

Outcome measures

- ☐ Complications (e.g. VAP, pneumothorax).

13.4 Process for selecting problem to focus on in the ICU and quality improvement process

This flowchart provides a framework for selecting a problem to focus on for quality improvement among the many that might be considered. It also shows the essential steps in the **plan-do-study-act** cycle (used with permission from Dr Andre Amaral, Sunnybrook Health Sciences Centre and University of Toronto, Toronto, Canada).



13.5 Checklist for initiating, improving, evaluating, and sustaining a quality improvement programme

☑ This checklist provides steps for initiating, improving, evaluating and sustaining a quality improvement programme in the ICU (adapted from Curtis et al, 2006) (see References and resources).

Initiating or improving a quality improvement programme

- ☐ Do background work: identify motivation, support team and develop strong leadership.
- ☐ Prioritize potential projects and choose the projects to begin.
- ☐ Prepare for the project by operationalizing the measures, building support for the project and developing a business plan.
- ☐ Do an environmental scan to understand the current situation (structure, process or outcome), the potential barriers, opportunities and resources for the project.
- ☐ Create a data collection system to provide accurate baseline data and document improvement.
- ☐ Create a data reporting system that will allow clinicians and other stakeholders to see and understand the problem and the improvement.
- ☐ Introduce strategies to change clinician behaviour and create the change that will produce improvement.

Evaluating and sustaining a quality improvement programme

- ☐ Determine whether the target is changing with ongoing observation, periodic data collection and interpretation.
- ☐ Modify behaviour change strategies to improve, regain or sustain improvements.
- ☐ Focus on sustaining interdisciplinary leadership and collaboration for the quality improvement programme.
- ☐ Develop and sustain support from the hospital leadership.

Common ICU quality indicators

- ☐ Deep venous thrombosis prophylaxis – number of patients receiving prophylaxis per eligible day.
- ☐ Stress ulcer prophylaxis – percentage of patients receiving prophylaxis per eligible day.
- ☐ Ventilator-associated pneumonia prevention strategies – percentage of patients receiving ventilator-associated pneumonia bundle per eligible day.
- ☐ Central venous catheter blood stream infection prevention strategies – percentage of patients receiving checklist per eligible central venous catheter insertion.

14 Ethical considerations

14 Ethical considerations

Summary

During a pandemic, the need for critical care services can exceed available resources. Triage decisions may need to be made on how to allocate scarce resources and prioritize patients.

Five ethical principles that can guide triage include: utility, maximum life-years saved, first-come first-served, random selection, and life cycle.

Public engagement in pandemic preparedness is essential to develop a prioritization strategy that is fair, transparent and builds trust.

Tools

14.1 Ethical principles
14.2 Sequential Organ Failure Assessment (SOFA) score
14.3 Paediatric Logistic Organ Dysfunction (PELOD-2) score
14.4 Framework for critical care triage during pandemic or disaster: American College of Chest Physicians consensus statement
14.5 Framework to guide allocation of scarce mechanical ventilation during disasters

References and resources

Biddison LD, Berkowitz KA, Courtney B, De Jong CM, Devereaux AV, Kissoon N et al. Ethical considerations: care of the critically ill and injured during pandemics and disasters: CHEST consensus statement. Chest. 2014;146(4 suppl):e145S–55S.

CDC. Ethical considerations for decision making regarding allocation of mechanical ventilators during a severe influenza pandemic or other public health emergency. Prepared by the Ventilator Document Workgroup for the Ethics Subcommittee of the Advisory Committee to the Director. Atlanta (GA): Centers for Disease Control and Prevention; 2011 (https://www.cdc.gov/od/science/integrity/phethics/docs/Vent_Document_Final_Version.pdf, accessed 3 July 2019).

Christian MD, Fowler R, Muller MP, Gomersall C, Sprung CL, Hupert N et al. Critical care resource allocation: trying to PREEDICCT outcomes without a crystal ball. Crit Care. 2013;17(1):107.

Christian MD, Sprung CL, King MA, Dichter JR, Kissoon N, Devereaux AV et al. Triage: care of the critically ill and injured during pandemics and disasters: CHEST consensus statement. Chest. 2014;146(4 suppl):e61S–74S.

Daugherty-Biddison EL, Faden R, Gwon HS, Mareiniss DP, Regenberg AC, Schoch-Spana M et al. Too many patients...a framework to guide statewide allocation of scarce mechanical ventilation during disasters. Chest. 2019;155:848-854 (https://www.ncbi.nlm.nih.gov/pubmed/30316913, accessed 20 March 2020).

Ferreira, FL, Bota DP, Bross A, Mélot C, Vincent JL. Serial evaluation of the SOFA score to predict outcome in critically ill patients. JAMA. 2001;286(14):1754–1758.

Leteurtre S, Duhamel A, Salleron J, Grandbastien B, Lacroix J, Leclerc F et al. PELOD-2: an update of the PEdiatric Logistic Organ Dysfunction score, Crit Care Med, 2013;41(7):1761-73.

Shahpori R, Stelfox HT, Doig CJ, Boiteau PJ, Zygun DA. Sequential organ failure assessment in H1N1 pandemic planning. Crit Care Med. 2011;39(4):827–32.

Smith MJ, Silva DS. Ethics for pandemics beyond influenza: Ebola, drug-resistant tuberculosis, and anticipating future ethical challenges in pandemic preparedness and response. Monash Bioeth Rev. 2015;33(2–3):130–47.

Swiss Confederation. Swiss influenza pandemic plan. Swiss Federal Office of Public Health; 2018 (https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/pandemievorbereitung/pandemieplan.html, accessed 4 July 2019).

WHO. Addressing ethical issues in pandemic influenza planning. Discussion papers. Geneva: World Health Organization; 2008.

WHO. Ethical considerations in developing a public health response to pandemic influenza. Geneva: World Health Organization; 2007.

WHO. Guidance for managing ethical issues in infectious disease outbreaks. Geneva: World Health Organization; 2016 (https://apps.who.int/iris/bitstream/handle/10665/250580/9789241549837-eng.pdf?sequence=1, accessed 20 March 2020).

Winsor S, Bensimon CM, Sibbald R, Anstey K, Chidwick P, Coughlin K et al. Identifying prioritization criteria to supplement critical care triage protocols for the allocation of ventilators during a pandemic influenza. Healthc Q. 2014;17(2):44–51.

14.1 Ethical principles

Ethical analysis involves identifying relevant principles, applying them to a particular situation, and making judgements about how to weigh competing principles when it is not possible to satisfy them all.

Key ethical principles and descriptions

Ethical principle	Description
Justice	Encompasses *equity* – fairness in the distribution of resources, opportunities and outcomes – and procedural justice – a fair process for making important decisions.
Equity	Treating like cases alike, avoiding discrimination and exploitation, and being sensitive to persons who are especially vulnerable to harm or injustice.
Procedural justice	Includes: • Due process – notice to persons and an opportunity to be heard • Transparency – clear, accurate information about the basis for decisions and decision-making process • Inclusiveness/community engagement – ensuring all relevant stakeholders participate • Accountability – allocating and enforcing responsibility for decisions • Oversight – ensuring appropriate mechanisms for monitoring and review
Beneficence	Acts done for the benefit of others (e.g. efforts to relieve individuals' pain and suffering). In the public health context, it is society's obligation to meet the basic needs of individuals and communities (e.g. nourishment, shelter, good health, security).
Utility	Actions are right insofar as they promote the well-being of individuals or communities. Efforts to maximize utility require consideration of proportionality – balancing potential benefits against risks of harm – and efficiency – achieving the greatest benefits at the lowest possible cost.
Respect for persons	Treating individuals in recognition of our common humanity, dignity and inherent rights. Key aspects include: autonomy; informed consent; privacy; confidentiality; social, religious and cultural beliefs; important relationships (e.g. family); and transparency and truth telling in public health and research.
Autonomy	Letting individuals make their own choices based on their values and preferences.
Informed consent	Process in which a competent individual authorizes a course of action based on sufficient relevant information, without coercion or undue inducement.
Liberty	Includes a broad range of social, religious and political freedoms (e.g. freedom of movement, peaceful assembly, speech), many of which are protected as fundamental human rights.
Reciprocity	Consists of making a "fitting and proportional return" for contributions that people have made.
Solidarity	Social relation in which a group, community, nation, or global community stands together. Justifies collective action in the face of common threats and supports efforts to overcome inequalities that undermine the welfare of minorities and groups that suffer from discrimination.

Source: Adapted from *Guidance for managing ethical issues in infectious disease outbreaks* (WHO, 2016).

14.2 Sequential Organ Failure Assessment (SOFA) score

The SOFA score is commonly used to describe and quantify organ failure and can also be used to predict outcome. The SOFA score has been proposed for use in triage strategies because it helps to quantify the principle of utility. To use the SOFA scoring system for triage, add the points for each clinical characteristic at presentation and then at 48 hours. Both the initial and 48-hour scores are predictive of mortality. The maximum score is 24. In the publication by Ferreira et al (2001) (see References and resources), an initial SOFA score of > 11 was associated with 95% mortality, whereas ≤ 9 was associated with 33% mortality.

Except for initial scores of > 11, a decreasing score during the first 48 hours was associated with a mortality rate of < 6%. An unchanged or increasing score during the first 48 hours was associated with a mortality rate of 37% when the initial score was 2–7; and 60% when the initial score was 8–11.

Note: More recent evaluations of this triage performance tool have not shown such consistent predictive value. This score uses the following triage variables. Also, this score has not been validated in children.

Sequential Organ Failure Assessment (SOFA) score

Variables	0	1	2	3	4
Respiratory PaO_2/FiO_2, mmHg	> 400	≤ 400	≤ 300	≤ 200[a]	≤ 100[a]
Coagulation Platelets × $10^3/\mu L$[b]	> 150	≤ 150	≤ 100	≤ 50	≤ 20
Liver Bilirubin, mg/dL[b]	< 1.2	1.2–1.9	2.0–5.9	6.0–11.9	> 12.0
Cardiovascular Hypotension	No hypotension	Mean arterial pressure < 70 mmHg	dop ≤ 5 or dob (any dose)	dop > 5, epi ≤ 0.1, or norepi ≤ 0.1[c]	dop > 15, epi > 0.1, or norepi > 0.1[c]
Central nervous system Glasgow Coma Score Scale	15	13–14	10–12	6–9	< 6
Renal Creatinine, mg/dL[d] or urine output, mL/day	< 1.2	1.2–1.9	2.0–3.4	3.5–4.9 or < 500	> 5.0 or < 200

Notes:
[a] Values are with respiratory support;
[b] To convert bilirubin from mg/dL to µmol/L, multiply by 17.1;
[c] Adrenergic agents administered for at least 1 hour (doses given are in µg/kg per minute);
[d] To convert creatinine from mg/dL to µmol/L, multiply by 88.4;
Norepi – norepinephrine; dob – dobutamine; dop – dopamine; epi – epinephrine; FiO_2, – fraction of inspired oxygen.

14.3 Paediatric Logistic Organ Dysfunction (PELOD–2) score

Multiple organ dysfunction syndrome is a frequent cause of death in adult and paediatric ICUs. The Paediatric Logistic Organ Dysfunction score was developed to describe the severity of age-specific organ dysfunction in children and has since been validated in many settings. This descriptive score relies on ten variables that correspond to five different organ dysfunctions. Any increased organ dysfunction in the PELOD-2 score is closely related to an increased risk of mortality, but neurologic and respiratory dysfunctions are the most critical. In the population in which the PELOD-2 was developed, a score of 10 was associated with ~10% probability of mortality, while a score of 20 was associated with > 90% probability of mortality. However, the predicted risk of death is population specific and varies with resource availability.

Scoring the Paediatric Logistic Organic Dysfunction (PELOD-2) score

Organ dysfunctions and variables[a]	Points by severity levels						
	0	1	2	3	4	5	6
Neurologic[b]							
Glasgow Coma Score	≥ 11	5–10			3–4		
Pupillary reaction	Both reactive					Both fixed	
Cardiovascular[c]							
Lactatemia (mmol/L)	< 5.0	5.0–10.9			≥ 11.0		
Mean arterial pressure (mmHg)							
0 to < 1 mo	≥ 46		31–45	17–30			≤ 16
1–11 mo	≥ 55		39–54	25–38			≤ 24
12–23 mo	≥ 60		44–59	31–43			≤ 30
24–59 mo	≥ 62		46–61	32–44			≤ 31
60–143 mo	≥ 65		49–64	36–48			≤ 35
≥ 144 mo	≥ 67		52–66	38–51			≤ 37
Renal							
Creatine (µmol/L)							
0 to < 1 mo	≤ 69		≥ 70				
1–11 mo	≤ 22		≥ 23				
12–23 mo	≤ 34		≥ 35				
24–59 mo	≤ 50		≥ 51				
60–143 mo	≤ 58		≥ 59				
≥ 144 mo	≤ 92		≥ 93				
Respiratory[d]							
PaO_2 (mmHg)/FiO_2	≥ 61		≤ 60				
$PaCO_2$ (mmHg)	≤ 58	59–94		≥ 95			
Invasive ventilation	No			Yes			
Haematologic							
WBC count (x 10^9/L)	> 2		≤ 2				
Platelets (x 10^9/L)	≥ 142	77–141	≤ 72				

[a] All variables must be collected, but measurements can be done only if justified by the patient's clinical status. If a variable is not measured, it should be considered normal. If a variable is measured more than once in 24 hours, the worst value is used in calculating the score. FiO_2: fraction of inspired oxygen.
[b] Neurologic dysfunction: Glasgow Coma Score: use the lowest value. If the patient is sedated, record the estimated Glasgow Coma Score before sedation. Assess only patients with known or suspected acute central nervous system disease. Pupillary reactions: nonreactive pupils must be > 3 mm. Do not assess after iatrogenic pupillary dilation.
[c] Cardiovascular dysfunction: heart rate and mean arterial pressure: do not assess during crying or iatrogenic agitation.
[d] Respiratory dysfunction: PaO_2 used: use arterial measurement only. PaO_2/FiO_2 ratio is considered normal in children with cyanotic heart disease. $PaCO_2$ can be measured from arterial, capillary or venous samples. Invasive ventilation; the use of mask ventilation is not considered invasive ventilation.

Logit (mortality) = -6.61 + 0.47 x PELOD-2 score.

Probability of death = 1(1 + exp [-logit(mortality)])

Source: Leteurtre et al (2013).

14.4 Framework for critical care triage during pandemic or disaster: American College of Chest Physicians consensus statement

This is adapted from the recently published American College of Chest Physicians consensus statement (Biddison et al, 2014) (see References and resources). It is presented as a framework only, and has not been validated in any population.

Conceptualized framework for how the critical care (tertiary) triage process and decisions would flow in a disaster or pandemic

Triage process decision flow

1 Inclusion criteria:

a) Refractory hypoxia require ventilation
b) Hypotension refractory to volume resuscitation and requiring vasopressor/inotropic support

2 Exclusion criteria:

a) Low probability of survival criteria
   i. Cardiac arrest
   ii. Severe trauma
   iii. Severe burns
   iv. Severe irreversible neurologic event or condition
   v. Severe prematurity

b) Short life expectancy criteria
   i. Metastatic malignancies
   ii. Haematologic malignancies with poor prognosis
   iii. End-stage organ failure with expected survival < 1 year
   iv. Very advanced age
   v. Advanced and irreversible immunocompromise
   vi. Congenital anomalies with expected survival < 1 year

3 Prioritization:

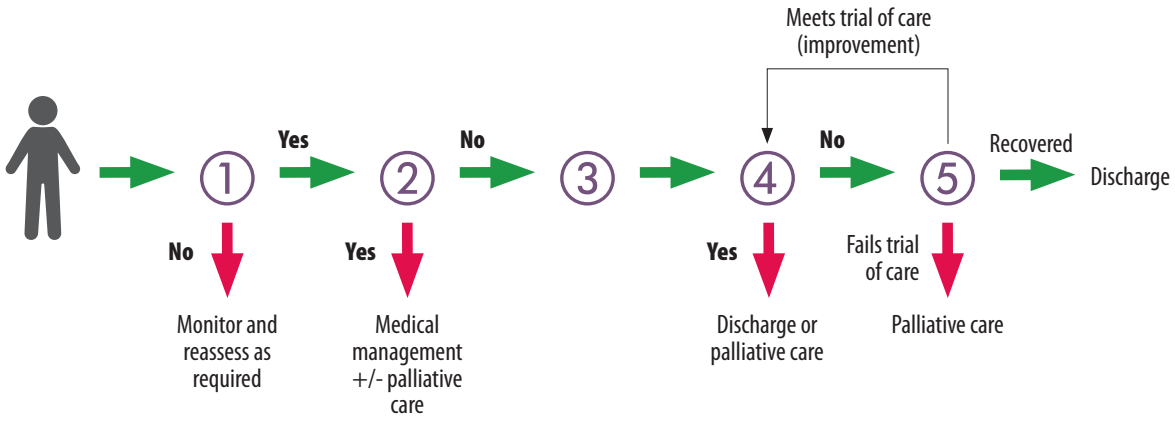
Admit to ICU based upon priority and as bed available

4 Daily reassessment:

Assess for development of exclusion criteria or discharge criteria

5 72 hour trial of care:

Did patient meet the goals of the trial of care is showing significant evidence of improvement?



14.5 Framework to guide allocation of scarce mechanical ventilators during disasters

Proposed strategy for ventilator allocation in epidemics of novel respiratory pathogens

		Point system			
Principle	**Specification**	**1**	**2**	**3**	**4**
Prognosis for short-term survival	Adults (SOFA) or paediatrics (PELOD-2)	SOFA score: ≤ 8 PELOD-2: ≤ 12	SOFA score: 9–11 PELOD-2: 12–13	SOFA score: 12–14 PELOD-2: 14–16	SOFA score: > 14 PELOD-2: ≥ 17
Prognosis for long-term survival	Prognosis for long-term survival (assessment of comorbid conditions)	—	—	Severe comorbid death likely within 1 year	—
Secondary considerations					
Lifecycle considerations	Prioritize those who have had the least chance to live through life's stages (age)	Age 0–49 years	Age 50–69 years	Age 70–84 years	Age ≥ 85 years

Examples of severe comorbid conditions with associated life expectancy < 1 year. This list is meant as a guideline and is not exhaustive. Patients meeting the criteria of < I year predicted survival based on which of the listed or other similar conditions should be assigned a score of 3.

1. NYHA class IV heart failure. 2. Advanced lung disease with FEV_1 < 25% predicted, total lung capacity < 60% predicted, or baseline PaO_2 < 55 mmHg. 3. Primary pulmonary hypertension with NYHA class III or IV heart failure. 4. Chronic liver disease with Child-Pugh score > 7. 5. Severe trauma. 6. Advanced untreatable neuromuscular disease. 7. Metastatic malignant disease or high-grade brain tumors.

NYHA – New York Heart Association.

Source: Daugherty-Biddison et al (2019).

For more information, please contact:

Emerging Diseases Clinical Assessment and Response Network
World Health Organization
Avenue Appia 20
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