

Supplementary Appendix A

Table A.1. Bundle Card for Component A in the Liberation Bundle

Card Overview

- **Card Definition:** A - Assessment, Prevention, and Management of Pain.
- **Purpose:** To observe the pain level, assign the pain score, and document significant pain assessment.

Assessment Instruments

- Critical Care Pain Observation Tool (CPOT) is four-item scale – vocalization, body movements, facial expression, and muscle tension – each scored from 0 to 2.
- Alternative pain assessment tools: Numeric Pain Rating Scale (NRS), and Behavioral Pain Scale (BPS)

Compliance Checks

- Significant pain level is defined as CPOT > 2, or BPS > 5, or NRS > 3
- Conduct pain assessments at least 6 times within 24 hours to monitor compliance.

Mapping to Standard Vocabularies: CPOT

Clinical Concept	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
CPOT: Muscle Tension Score	0: Relaxed 1: Tense, Rigid 2: Very tense or rigid	OMOP Extension: OMOP5214828, ID: 722052	Measurement
CPOT: Vocalization Score	0: No sound 1: Sighing, moaning 2: Crying out, groaning	OMOP Extension: OMOP5214836, ID: 722060	Measurement
CPOT: Body Movements Score	0: No movement 1: Protection 2: Restlessness	OMOP Extension: OMOP5214824, ID: 722048	Measurement
CPOT: Facial Expression Score	0: Relaxed, neutral 1: Tense 2: Grimacing	OMOP Extension: OMOP5214820, ID: 722044	Measurement
CPOT: Total Score	Sum of scores from each of the four indicators	OMOP Extension: OMOP5214819, ID: 722043	Measurement

Alternative Pain Assessment Tools

Clinical Concept	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
Numeric Pain Rating Scale (NRS)	Rate pain on a scale of 0 to 10	SNOMED: 1284852002, ID: 37151627	Measurement
Behavioral Pain Scale (BPS)	Facial expression, Upper limb movements, and compliance with mechanical ventilation	SNOMED: 273313008, ID: 3399022	Measurement

Table A.2. Bundle Card for Component B in the Liberation Bundle – Part I

Card Overview

- **Card Definition:** B: SAT - Spontaneous Awakening Trials.
- **Purpose:** To assess the ability to breathe without assistance by periodically stopping sedative drugs for mechanically ventilated patients.

Assessment Instruments

- Assess whether the patient has received sedatives or opioid medications.
- Observe whether the sedative medium is continuous (IV-infusion) or intermittent (Bolus).

Compliance Checks

- Periodically stop or pause sedatives for mechanically intubated patients to help weaning from ventilation.
- Record if patients were successfully weaned from mechanical ventilation during the trial.

Mapping to Standard Vocabularies

Clinical Concept	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
Sedative	Midazolam, Propofol, Lorazepam, Dexmedetomidine, etc.	SNOMED: 372614000, ID: 4156741	Drug
Sedative Route	<ul style="list-style-type: none"> • Continuously Infused • Intermittent/Bolus Scheduled • PRN (“as needed”) 	SNOMED: 72641008, ID: 4219502	Procedure
SAT Assessment	Sedative Medication Stopped or Paused	SNOMED: 424282004, ID: 4312631	Procedure
SAT Failure	<ul style="list-style-type: none"> • Anxiety, agitation, or pain • Respiratory rate > 35/min • Oxygen saturation < 88% • Respiratory distress • Acute cardiac arrhythmia 	SNOMED: 407563006, ID: 4253173	Observation

Table A.3 Bundle Card for Component B in the Liberation Bundle – Part II

Card Overview

- **Bundle Component:** B: SBT - Spontaneous Breathing Trials.
- **Purpose:** To assess the ability to breathe without assistance by temporarily reducing or removing mechanical ventilatory support.

Assessment Instruments

- Assess whether the patients are on mechanical ventilation modes, such as PSV, CPAP, or SPONT ventilation support.
- Start the SBT trial if the patient meets the criteria of Oxygen saturation $\geq 88\%$, $FiO_2 < 50\%$ and PEEP < 7.5 cmH₂O. Record the results if started or not.
- Reduce mechanical support, monitor the patient's ability to sustain independent breathing, and adjust ventilator settings such as PEEP and FiO_2 as needed to perform the SBT.

Compliance Checks

- Record the results if a patient completed the trial or documented the reason for the failure of different.

Mapping to Standard Vocabularies

Clinical Concept	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
Ventilation Modes	<ul style="list-style-type: none"> • PSV: Pressure Support Ventilation • SPONT: Spontaneous • CPAP: Continuous Positive Airway Pressure • SIMV: Synchronized Intermittent Mandatory Ventilation • APRV: Airway Pressure Release Ventilation 	SNOMED: 1258985005, ID: 37158404	Procedure
SBT Started	Yes or No	LOINC: 93203-8, ID: 1001774	Observation
SBT Stopped	<ul style="list-style-type: none"> • RR > 35 for > 5 min • Accessory Muscle Use • $SpO_2 < 90\%$ for > 2 min • BP > 180 or < 90 • HR > 140 • Arrhythmia 	SNOMED: 407563006, ID: 4253173	Observation
SBT Completion	Yes or No	LOINC: 87542-7, ID: 36305814	Observation
SBT Deferred	<ul style="list-style-type: none"> • Unable to perform RSBI • Chronic vent dependent patient • Pending procedure • RSBI > 105 	SNOMED: 416237000, ID: 4168192	Observation

RSBI: Rapid shallow breathing index

Table A.4. Bundle Card for Component C in the Liberation Bundle

Card Overview

- Bundle Component: C - Choice of Analgesia and Sedation levels
- Purpose: To select appropriate sedation and analgesia levels

Assessment Instruments

- Establish individual sedation level targets based on Richmond Agitation-Sedation Scale (RASS), a 10-point scale.

Compliance Checks

- Perform Arousal Assessments: Conduct arousal assessments at least 6 times within 24 hours to monitor compliance with the sedation targets.
- Continuously evaluate and adjust sedation and analgesia such as Fentanyl and Dexmedetomidine
- Record the results of each assessment, including those outside the sedation target

Mapping Standard Vocabulary

Clinical Concept	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
RASS Score	Ranges: +4 (Combative) to -5 (Unarousable)	SNOMED: 457441000124102, ID: 36684829	Measurement
Goal RASS Score	Ranges: 0 (Alert and Calm) to -2 (Light sedation).	SNOMED: 457441000124102, ID: 36684829	Measurement
Sedative Medications	See list below	RxNorm	Drug
Analgesic Medications	See list below	RxNorm	Drug

<i>Sedatives</i>	<i>Analgesics</i>
<ul style="list-style-type: none"> • Alprazolam • Amobarbital sodium • Ativan • Clonazepam • Dexmedetomidine • Diazepam • Ketamine • Lorazepam • Mephobarbital • Midazolam • Pentobarbital • Phenobarbital • Propofol 	<ul style="list-style-type: none"> • Codeine Phosphate • Codeine sulfate • Fentanyl • Ketamine • Meperidine • Hydromorphone • Methadone • Mod-oxycodone • Morphine • Oxycodone

Table A.5. Bundle Card for Component D in the Liberation Bundle

Card Overview

- **Bundle Component:** D - Delirium: Assess, Prevent, and Manage
- **Purpose:** To assess delirium status from changes in consciousness, inattention, and mental status

Assessment Instruments

- Administer the Confusion Assessment Method for the ICU (CAM-ICU)²⁵

Compliance Checks

- Conduct delirium assessments at least 2 times within 24 hours to monitor compliance.

Mapping to Standard Vocabularies

Clinical Concept	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
CAM-ICU RASS LOC	Yes or No	LOINC: 95857-9, ID: 36031363	Observation
CAM-ICU mental status Change	Yes or No	LOINC: 54632-5, ID: 40757763	Observation
CAM-ICU Inattention	<ul style="list-style-type: none"> • Yes (3 or more errors) • No (less than 3 errors) • Unable to Assess (UTA) • Language Barrier • Preexisting Advanced Dementia 	LOINC: 106402-1, ID: 1092114	Observation
CAM-ICU Altered LOC	Yes or No	LOINC: 95815-7, ID: 36031661	Observation
CAM-ICU Disorganized thinking	Yes or No or UTA	LOINC: 95814-0, ID: 36031539	Observation
Delirium Assessment Status	<ul style="list-style-type: none"> • Positive • Negative • UTA 	SNOMED: 733870009, ID: 37116854	Procedure

Table A.6. Bundle Card for Component E in the Liberation Bundle

Card Overview

- Bundle Component: E - Early Mobility and Exercise
- Purpose: To encourage early physical activity to prevent muscle weakness and fasten the overall recovery.

Compliance Checks

- Evaluate the patient's mobility capabilities using exercises such as "Sit to Stand Ability" or "Transfer Ability".
- Document the results of each mobility or exercise
- After the initial evaluation, perform assessments for higher levels of exercise to further determine the patient's mobility range.
- Continuously observe and record the highest level of exercise or mobilization the patient achieves, noting any challenges or successes encountered.

Mapping to Standard Vocabulary

Clinical Concept	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
Range of Motion (ROM) Status	<ul style="list-style-type: none"> • Passive • Active 	SNOMED: 228528009, ID: 4036092	Procedure
Sit to Stand Ability	<ul style="list-style-type: none"> • min A (Minimal Assistance) • mod A (Moderate Assistance) • max A (Maximum Assistance) • Contact guarding. • Independent • Supervision 	LOINC: 89393-3, ID: 36306060	Observation
Activity / Mobility	<ul style="list-style-type: none"> • Lift to chair/bed • Turning in bed • Chair: Transfer to chair/bed • Stand: >= One minute • Walk: 10+/25+/250+ Feet 	SNOMED: 363803005, ID: 4178501	Observation
Transfer Ability	<ul style="list-style-type: none"> • Stand step • Stand pivot • Contact guarding • Supervision • Squat pivot • Slide board • Independent 	LOINC: 83185-9, ID: 42529379	Observation

Table A.7. Bundle Card for Component F in the Liberation Bundle

Card Overview

- Bundle Component: F - Family Engagement and Empowerment
- Purpose: To involve and engage families in the care process

Compliance Checks

- Record each instance of family visit, call, or communications with healthcare providers, including nurses and doctors.
- Hold family meetings to discuss the patient's care plan, ensuring consistent family involvement.
- Ensure that family decision-makers are informed about the ICU Liberation Bundle and the patient's care status.
- Allow and track family or friends participation in care rounds, noting their contribution to decision-making processes.

Mapping to Standard Vocabularies

Clinical Idea	Concept Values	Standardized Vocabulary: Code, Concept ID	CDM Table
Family Communication	<ul style="list-style-type: none"> • Family Visited • Family Talked to Registered Nurse • Family Called • Family Talked to Doctor • Family Conference 	SNOMED: 14641000202103, ID: 1450126	Observation
Family Meeting	Yes or NO	SNOMED: 711070007, ID: 46272666	Observation
Family Informed	<ul style="list-style-type: none"> • Yes • No • Not Applicable 	SNOMED: 406141002, ID: 4247377	Observation

Supplementary Appendix B

Component A: Regular Expressions Used to Retrieve Concepts Name

Regular Expression	MIMIC-IV, Itemid's	Concept Name
<code>\b(?:cpot[-\s:]*)?muscle\s+tension(?:\s*(cpot[ab]\s*))?\b</code>	229691, 229692	CPOT-Muscle Tension (CPOTb), CPOT-Muscle Tension (CPOTa)
<code>\b(?:cpot[-\s:]*)?vocali[sz]ation(?:\s*(cpot[ab]\s*))?(?:_old_\d+)\b</code>	229694, 229695	CPOT-Vocalization (CPOTa), CPOT-Vocalization (CPOTb)
<code>\b(?:cpot[-\s:]*)?body\s+movements(?:\s*(cpot[ab]\s*))?\b</code>	229696, 229697	CPOT-Body Movements (CPOTb), CPOT-Body Movements (CPOTa)
<code>\b(?:cpot[-\s:]*)?facial\s+expression(?:\s*(cpot[ab]\s*))?\b</code>	229698, 229699	CPOT-Facial Expression (CPOTb), CPOT-Facial Expression (CPOTa)

Component B: Regular Expressions Used to Retrieve Concepts Name

Regular Expression	MIMIC-IV, Itemid's	Concept Name
<code>\bventilator[-\s:]*mode\b</code>	223849, 229314	Ventilator Mode, Ventilator Mode (Hamilton)

\bsbt[-\s:]*started?\b	224715	SBT Started
\bsbt[-\s:]*success(?:fully)?\b	224717	SBT Successfully Completed
\bsbt[-\s:]*defer(?:red)?\b	224833	SBT Deferred

Component C: Regular Expressions Used to Retrieve Concepts Name

Regular Expression	MIMIC-IV, Itemid's	Concept Name
(?)\bRichmond[-\s]*RAS{1,2}[-\s]*Scale\b	228096, 228299	Richmond-RAS Scale, Goal Richmond-RAS Scale
\b(?:sedative(?:s)? sedation)\b(?:\s*[:/-])?	230116	Sedatives
(\b(?:analgesic(?:s)? analgesia)\b(?:\s*[:/-])?)	230117	Analgesics

Component D: Regular Expressions Used to Retrieve Concepts Name

Regular Expression	MIMIC-IV, Itemid's	Concept Name
(?)\bCAM[-\s]*ICU[-\s]+RASS[-\s]+LOC\b	228302	CAM-ICU RASS LOC
(?)\bCAM[-\s]*ICU[-\s]+ms[-\s]+change\b	228300, 228337, 229326	CAM-ICU MS change
(?)\bCAM[-\s]*ICU[-\s]+inattention\b	228301, 228336, 229325	CAM-ICU Inattention
(?)\bCAM[-\s]*ICU[-\s]+altered[-\s]+LOC\b	228334	CAM-ICU Altered LOC
(?)\bCAM[-\s]*ICU[-\s]+disorgani[sz]ed[-\s]+thinking\b	228303, 228335, 229324	CAM-ICU Disorganized thinking
(?)\b(?:delirium(?:s)? delirium[-\s]+assessment[-\s]+status)\b	228332, 228688	Delirium assessment, Delirium

Component E: Regular Expressions Used to Retrieve Concepts Name

Regular Expression	MIMIC-IV, Itemid's	Concept Name
(?)\bRange[-\s]+of[-\s]+Motion\b	224092, 225176	Range of Motion Location, Range of Motion Status
(?)\b(?:Gait[-\s]+Transfer+ing Transfers?)\b	227848, 227345	Transfer, Gait/Transferring
(?)\bSit[-\s]*to[-\s]*Stand\b	227847	Sit to Stand
(?)\bMobilization[-\s]+Plan\b	228697	Mobilization Plan

Component F: Regular Expressions Used to Retrieve Concepts Name

Regular Expression	MIMIC-IV, Itemid's	Concept Name
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(?)\bFamily\b	228125, 228128, 228129, 224024, 227960, 224447	Family meeting held, Family updated by MD, Family updated by RN, Family Communication, Patient/Family Informed, Family Meeting
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