**Supplemental Digital Content**

**Table SDC1.** **Complete List of Patient Impact Event Taxonomy for 171 Non-Routine Events**

|  |  |  |  |
| --- | --- | --- | --- |
| Code | Code | Event | Count\* (% total Non-Routine Events, n=171) |
| **100** |  | **Nervous System\*** | **13 (7.6%)** |
| **150** |  | **Neuromuscular System Problems** | **9 (5.3%)** |
|  | 152 | Abnormal movement (e.g., intraoperative movement) | 7 (4.1%) |
|  | 153 | Abnormal tone (e.g., muscle rigidity) | 1 (0.6%) |
| **160** |  | **Agitation/Psychosis** (Emergence Delirium) | **2 (1.2%)** |
| **170** |  | **Pain** | **3 (1.8%)** |
|  | 171 | Procedure-induced pain (e.g., unrelieved by current anesthetic) | 1 (0.6%) |
|  | 172 | Severe post-operative pain | 2 (1.2%) |
| **180** |  | **Unanticipated Delayed Emergence (>1 hour)** | **1 (0.6%)** |
| **200** |  | **Cardiovascular System** | **64 (37.4%)** |
| **210** |  | **Myocardial Ischemia/Infarction (<48hrs)** | **6 (3.5%)** |
|  | 213 | Myocardial ischemia (electrocardiogram evident) | 5 (2.9%) |
|  | 216 | Chest tightness | 1 (0.6%) |
| **220** |  | **Cardiac Arrest** | **2 (1.2%)** |
|  | 221 | Asystole | 2 (1.2%) |
| **230** |  | **Other Cardiac Dysrhythmias** | **13 (7.6%)** |
|  | 231 | Sinus tachycardia (>120 bpm) [Different criteria for pediatrics] | 1 (0.6%) |
|  | 232 | Sinus bradycardia (< 50 bpm) [different criteria for pediatrics] | 10 (5.8%) |
|  | 237 | Ventricular Premature Complexes | 3 (1.8%) |
|  | 238 | Atrial Premature Complexes | 1 (0.6%) |
| **240** |  | **Cardiac Conduction System Problems** | **1 (0.6%)** |
|  | 241 | Stable atrioventricular block (1°, Mobitz 1) | 1 (0.6%) |
| **260** |  | **Unstable Hemodynamics** | **55 (32.2%)** |
|  | 261 | Hypertension >33% above baseline, controllable | 18 (10.5%) |
|  | 262 | Hypertension >33% above baseline, refractory to treatment | 1 (0.6%) |
|  | 263 | Hypotension (blood pressure <80/40 mmHg or <33%), controllable | 34 (19.9%) |
|  | 264 | Hypotension (blood pressure <80/40 mmHg or <33%), refractory | 3 (1.8%) |
|  | 265 | Autonomic dysreflexia | 1 (0.6% |
| **270** |  | **Shock** | **1 (0.6%)** |
|  | 273 | Cardiogenic shock | 1 (0.6%) |
| **300** |  | **Pulmonary System** | **4 (2.3%)** |
| **360** |  | **Bronchospasm** | **4 (2.3%)** |
| **400** |  | **Respiratory Function Impairment** | **25 (14.6%)** |
| **410** |  | **Abnormal Blood Gas Analysis** | **17 (9.9%** |
|  | 411 | Desaturation (Sao2 or Spo2 < 90%) | 16 (9.4%) |
|  | 412 | Hypoxia (Pao2 < 50 mmHg) | 1 (0.6%) |
| **420** |  | **Abnormal respiratory rate/function** | **12 (7.0%)** |
|  | 424 | Hypoventilation | 12 (7.0%) |
| **430** |  | **Laryngospasm** | **3 (1.8%)** |
| **440** |  | **Failure to extubate as planned** | **3 (1.8%)** |
|  | 443 | Unstable hemodynamics | 1 (0.6%) |
|  | 444 | Prolonged operative procedure | 2 (1.2%) |
|  | 448 | Residual neuromuscular blockade | 1 (0.6%) |
| **450** |  | **Failure to extubate (other)** | **3 (1.85)** |
|  | 451 | Delayed emergence | 2 (1.2%) |
|  | 453 | Poor oxygenation | 1 (0.6%) |
| **500** |  | **Airway Associated Events** | **57 (33.3%)** |
| **510** |  | **Difficult mask ventilation (Spo2 < 90%)** | **5 (2.9%)** |
|  | 511 | Predicted | 2 (1.2%) |
|  | 512 | Unpredicted | 3 (1.8%) |
|  | 513 | Laryngeal mask airway insertion, unanticipated | 1 (0.6%) |
| **520** |  | **Difficult Tracheal Intubation** | **25 (14.6%)** |
|  | 521 | Anticipated, uncomplicated | 6 (3.5%) |
|  | 522 | Anticipated, complicated | 2 (1.2%) |
|  | 523 | Unanticipated, uncomplicated | 7 (4.1%) |
|  | 524 | Unanticipated, complicated | 4 (2.3%) |
|  | 526 | Difficulty with laryngeal mask airway placement | 6 (3.5%) |
| **530** |  | **Esophageal Intubation** | **13 (7.6%)** |
|  | 531 | Immediate recognition (<1 min) | 12 (7.0%) |
|  | 532 | Delayed recognition (>1 min) | 1 (0.6%) |
| **540** |  | **Endobronchial Intubation** | **4 (2.3%)** |
| **550** |  | **Unplanned Intubation/Re-Intubation** | **5 (2.9%)** |
|  | 551 | Unplanned intubation | 1 (0.6%) |
|  | 552 | Unplanned reintubation | 1 (0.6%) |
|  | 553 | Planned intubation, performed urgently | 1 (0.6%) |
|  | 554 | Endotracheal tube replacement, unplanned | **3 (1.8%)** |
| **560** |  | **Premature Extubation/Circuit disconnect** | **10 (5.8%)** |
|  | 562 | Accidental extubation/tube dislodgement | 2 (1.2%) |
|  | 563 | Anesthesia provider decision | 7 (4.1%) |
|  | 566 | Other breathing circuit leaks | 1 (0.6%) |
| **570** |  | **Airway Obstruction** (Unplanned/Prolonged) | **3 (1.8%)** |
|  | 572 | Airway secretions | 1 (0.6%) |
|  | 576 | Patient anatomy (e.g. tonsils, tongue) | 1 (0.6%) |
|  | 577 | Stridor/croup | 2 (1.2%) |
| **590** |  | **Airway/Dental Injury** | **5 (2.9%)** |
|  | 593 | Dental injury | 2 (1.2%) |
|  | 596 | Blood in airway | 2 (1.2%) |
| **600** |  | **Hematology / Renal / Gastrointestinal System** | **8 (4.7%)** |
| **610** |  | **Anemia (Hemoglobin < 8.0)** | **3 (1.8%)** |
| **650** |  | **Acute Blood Loss / Massive Transfusion** | **2 (1.2%)** |
|  | 651 | Massive volume resuscitation (>1x Blood Volume) | 2 (1.2%) |
|  | 652 | Massive bleeding from operative site | 2 (1.2%) |
| **670** |  | **Gastrointestinal Problems** | **5 (2.9%)** |
|  | 671 | Nausea | 2 (1.2%) |
|  | 672 | Vomiting | 2 (1.2%) |
| **700** |  | **Patient Disposition / Recovery** | **6 (3.5%)** |
| **720** |  | **Intensive Care Unit Admission** | **3 (1.8%)** |
|  | 722 | Unplanned intensive care unit admission | 3 (1.8%) |
| **740** |  | **Prolonged PACU stay (>6 hrs)** | **1 (0.6%)** |
| **770** |  | **Case Cancellation** | **3 (1.8%)** |
|  | 772 | Inadequate medical information (old chart, data, etc) | 1 (0.6%) |
|  | 777 | Surgeon indication | 2 (1.2%) |
|  | 778 | Patient indication | 1 (0.6%) |
| **800** |  | **Miscellaneous** | **22 (12.9%)** |
| **810** |  | **Regional Anesthesia Associated Complications** | **9 (5.3%)** |
|  | 818 | Unplanned regional to general anesthesia (failed regional anesthesia) | 5 (2.9%) |
| **820** |  | **Soft Tissue Injury (See also Positioning (135) and Airway (590) injuries)** | **1 (0.6%)** |
|  | 824 | Skin cut/abrasion (see also 943) | 1 (0.6%) |
| **830** |  | **Vascular Injury** | **5 (2.95)** |
|  | 834 | Unable to start intravenous catheter | 4 (2.3%) |
|  | 835 | Major vascular injury (e.g., pulmonary artery rupture) | 1 (0.6%) |
| **840** |  | **Surgical Non-Routine Events** | **7 (4.1%)** |
|  | 841 | Wrong site surgery (recoded from 840) | 1 (0.6%) |
|  | 844 | Issues of surgical technique | 1 (0.6%) |
|  | 845 | Issues of surgical decision making | 1 (0.6%) |
| **850** |  | **Body Temperature Abnormality** | **1 (0.6%)** |
|  | 851 | Hypothermia (<35°C) | 1 (0.6%) |
| **900** |  | **Human Factors, Drugs, and Equipment** | **53 (31.0%)** |
| **910** |  | **Drug Administration** | **22 (12.9%)** |
|  | 911 | Incorrect drug administered | 1 (0.6%) |
|  | 913 | Drug overdose | 8 (4.7%) |
|  | 914 | Drug underdose | 7 (4.1%) |
|  | 915 | Incorrect time of drug administration | 2 (1.2%) |
|  | 918 | Opioid overdose | 3 (1.8%) |
|  | 919 | Reversal agents (naloxone, flumazenil) given | 2 (1.2%) |
| **930** |  | **Equipment Problems** (includes all devices and supplies) | **26 (15.2%)** |
|  | 931 | Equipment unavailable | 2 (1.2%) |
|  | 932 | Anesthesia equipment failure/defect | 12 (7.0%) |
|  | 934 | Use error (e.g. mis-programming of intravenous pump) | 4 (2.3%) |
|  | 935 | Disconnect (Intravenous catheter, wires, etc.) | 6 (3.5%) |
|  | 936 | Problem with in-dwelling device (e.g., pacemaker, pulmonary artery catheter) | 2 (1.2%) |
| **940** |  | **Anesthesia Workstation Problems** | **2 (1.2%)** |
| **950** |  | **Events Leading to Patient Injury** | **5 (2.9%)** |
|  | 952 | Electric shock | 1 (0.6%) |
|  | 953 | Physical trauma | 1 (0.6%) |
|  | 954 | Psychological trauma | 2 (1.2%) |
|  | 955 | Fall | 1 (0.6%) |
| **960** |  | **Events Leading to Staff Injury** | **1 (0.6%)** |

\*Count reported at 10’s and 100’s level represents the number of NREs that have one **or more** Patient Impact Event codes at that level

**Table SDC2. Reliability of Ratings**

**Contributory Factor Intra-rater reliability**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PIE Categories** | **OPA (%)** | **PPA (%)** | **NPA (%)** | **Cohen’s Kappa** |
| Provider | 100.0 | 100.0 | 100.0 | 1.00 |
| Patient | 93.3 | 92.3 | 94.1 | 0.87 |
| Task/Process | 86.7 | 88.9 | 83.3 | 0.73 |
| Team | 80.0 | 85.7 | 66.7 | 0.56 |
| Environment † | 66.7 | - | - | - |
| Technology | 86.7 | 92.3 | 50.0 | 0.44 |
| Other | 86.7 | 88.9 | 83.3 | 0.73 |

**Patient Impact Event Inter-rater reliability**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PIE Categories** | **OPA (%)** | **PPA (%)** | **NPA (%)** | **Cohen’s Kappa** |
| 100 Level | 94.7 | 75.0 | 96.2 | 0.64 |
| 200 Level | 88.5 | 75.7 | 94.7 | 0.73 |
| 300 Level † | 98.2 | - | - | - |
| 400 Level | 89.4 | 77.8 | 91.6 | 0.64 |
| 500 Level | 92.9 | 84.4 | 98.5 | 0.85 |
| 600 Level | 95.6 | 66.7 | 96.4 | 0.42 |
| 700 Level | 96.5 | 100.0 | 96.4 | 0.59 |
| 800 Level | 93.8 | 84.6 | 95.0 | 0.72 |
| 900 Level | 82.3 | 84.2 | 81.3 | 0.61 |

**Table legend**. CF – Contributor Factor, OPA – Overall percent agreement, PPA – Positive percent agreement, PIE – Patient impact event, NPA – Negative percent agreement.

† Either the positive/positive or negative/negative cell was empty.

**Table SDC 3. Expert ratings**

|  |  |
| --- | --- |
| **CONES Rating (n = 173)** |  |
| **Patient Impact, N (%)** | 120 (69.4%) |
| **Near miss, N (%)** | 84 (48.6%) |
| **Patient Injury, N (%)** | 22 (12.7%) |
| **Reoccurrence, Median (IQR) (n = 147)** | 3.0 (2.0, 3.0) |
| **Reoccurrence Severity, Median (IQR) (n = 145)** | 2.0 (2.0, 3.0) |

**Table Legend**. CONES - Comprehensive Open-Ended Non-Routine Event Survey

**Table SDC4. Selected Non-Routine Events and their Associated Detailed Descriptions, Contributory Factors and Patient Impact Events**

|  |  |  |  |
| --- | --- | --- | --- |
| **Non-Routine Event # and Short Description** | **Non-Routine Event Long Description (summary narrative provided by domain expert reviewer)** | **Contributory Factors** | **Patient Impact Events** |
| 11140. Delay in obtaining blood products | Patient was losing blood as expected. Sees suction canister is full. Concerned about blood loss, resident obtains a hemoglobin value (Hemocube) and looks for the circulating registered nurse who was not in the operating room. Doesn't know who it is or how to get them. Asks the surgeons about how to get the circulator. Patient's vital signs stable. Resident curses and asks about the circulator. Woman enters the room and he hopes she is the circulator, then realizes she is a medical student. Resident wants to give blood but can't find the circulator. Never called anyone. Another physician comes into room and resident complains that it's been 15 minutes (only been 7 minutes). Circulator comes into room and resident states that he needs 2 units of blood right away. He never knew circulator's name. Resident became agitated and used angry tone with nurse. Blood pressure never dropped below mid-80's. Circulator comes back in the room with the blood and is at computer scanning the blood. Resident is pacing anxiously. | Communication (13), Inadequate Support (2), Logistical/Systems Issue (19), Staff Action or Inaction (11) | Hypotension, controllable (263), Anemia (610) |
| 11024. Unsafe act by resident | After placing an epidural, the resident disposed of all sharps items in the designated disposer. A few minutes later, the faculty enters the operating room and looks for the epidural tray… is informed by the resident that the tray has been already disposed. The faculty tells the resident to go look in the sharps container for the vial of epinephrine. | Communication (13), Error in Judgement (17), Inadequate Knowledge (16), Inadequate Supervision (15), Inexperience (14), Pre-existing Disease (8), Policies and Procedures (20), Surgical Requirements (5), Teaching (21) | Unable to start IV (834), Events Leading to Staff Injury (960) |
| 11126. Patient coughed and moved under general anesthesia leading to transient desaturation | In middle of case, during a break… [provider] realized that the neuromuscular relaxant had worn off and wanted to give more. No vials of [that] neuromuscular blocker left in cart. Patient began to move, buck, and then desaturated into the 80's. Attempted to deepen the volatile anesthetic… No manual ventilation. No intravenous agents given. Called attending. Cart had not been restocked. Attending asks if [relieving provider] had given any additional relaxant or sedative. Original provider returned, they discussed the problem, there were other neuromuscular blockers in the cart and a vial of neuromuscular blocker was drawn up on the top of the cart but [was] covered with stuff. | Logistical or Systems Issues (19), Patient Unexpected Response (9), Transfer of Care (6) | Abnormal Movement (152), Desaturation (411), Drug underdose (914) |
| 11320. Hypoventilation due to fentanyl administration in a spontaneously ventilating patient | Break provided after abbreviated handover and personal discussion… Fentanyl 50 mcg was given to the patient by the break person… Four minutes later, respiratory rate and tidal volume decreased with desaturation to 93%. 100% oxygen [was] delivered [but the] Spo2 dropped to 90%. Positive pressure ventilation started about 2 minutes later. Fio2 [was] decreased. Respiratory variation noted. Again, increased Fio2 to 100% and Spo2 gradually increased to 96% over next 5 minutes… Sevoflurane turned up [in response] to surgeon request for more relaxation. Original provider returns to room shortly thereafter. Relieving provider states that he gave 1 cc fentanyl but doesn't describe respiratory depression. During report, [relieving provider] gave several more manual ventilation breaths and Spo2 increased to 97%. | Communication (13), Error in Judgement (17), Inexperience (14), Pre-Existing Disease (8), Patient Unexpected Response (9) | Desaturation (411), Hypoventilation (424) |
| 11501. Inadvertent bolus of remifentanil prior to induction | About 25 min. into [the] case, [provider] concerned about quality of the intravenous catheter. Resident set up remifentanil dose at double strength and programmed the volumetric pump correctly for that dosage. Remifentanil infusion begun into poorly functioning IV. Pump alarming. New pump obtained and reprogrammed… Flushed intravenous catheter which then caused a bolus of remifentanil… remifentanil infusion restarted. Blood pressure 214/77, heart rate 85… Three minutes later, the patient becomes apneic and bag-mask ventilation instituted (possibly difficult ventilation at this time). Attending states "this patient probably got a bolus of remi[fentanil]". Within 20 seconds, [they] give propofol and cisatracurium and situation resolves. Provider starts new IV. | Equipment Usability (1), Error In Judgement (17), Pre-Existing Disease (8), Preoperative Preparation (7), Stress, Workload, or Fatigue (12) | Abnormal tone (153), Hypotension, controllable (263), Drug overdose (913),  Problem with in-dwelling device (936), Hypoventilation (424), Unable to start IV (834) |
| 11682. ETT removed with balloon still inflated | At the end of the surgical procedure, while preparing for extubation, the ETT had been untaped. The patient awoke and in the process of changing the ventilator to bag (100% oxygen was being delivered). As the ETT cuff was being deflated for extubation, the patient started to sit up and the ETT came out with the cuff inflated. | Patient Unexpected Response (9) | Patient self-extubation (561) |
| 11723. Premature extubation resulting in transient desaturation | Patient responded briefly, spontaneously to open eyes and mouth [to] command at end of surgery… Did not lift his head to command… Was less responsive but was extubated anyway because resident felt patient was not tolerating ETT (gagging plus hypertension). Briefly, post-extubation patient [was] still breathing (but largely unresponsive) and still hypertensive. Delay in getting oxygen by green mask on patient. First green [oxygen] tank was EMPTY. Progressive desaturation to <67% ultimately requiring two-person controlled [mask] ventilation. Resident felt cause was laryngospasm, but easy subsequent positive pressure ventilation seems to suggest was general hypoventilation followed by hypercarbia and hypoxemia leading to worsening hypoventilation. | Error in Judgement (17), Inadequate Knowledge (16), Inadequate Supervision (15), Inexperience (14), Interruption or Distraction (18), Patient Unexpected Response (9) | Sinus tachycardia (231), Hypertension, controllable (261), Hypoxemia (412), Anesthesia provider decision (563), Desaturation (411), Hypoventilation (424) |
| 11786. Airway obstruction and stridor upon removal of laryngeal mask airway | On emergence, while patient was deep, ProSeal laryngeal mask airway removed by student with Spo2 100%. Oral airway placed. Student holding face mask on patient; no jaw thrust. Sternal retractions observable. Resident distracted by end of case stuff. Resident started assisting student with Spo2 97% - showed student how to hold mask with jaw thrust. Resident turns around to get portable oxygen. Retractions visible again with mild stridor. Oxygen transport mask placed. Spo2 decreases to 96%. Resident listens to lungs. Jaw thrust performed [but] Spo2 still falling. Pulse ox[imeter] removed (last Spo2 94%). Moves patient to gurney. Resident lifts the jaw and patient begins to cough and buck. [Resident says,] "Wait let's hold on". Patient has audible stridor. Explains laryngospasm to student. Bag-mask positive pressure ventilation restarted with Spo2 of 79% [and] Spo2 [improves] to 98%. Oxygen transport mask placed but still can hear stridor. Goes back to bag-mask ventilation assistance [to maintain] Spo2 at 97%. | Error in Judgement (17), Patient Positioning (10), Patient Unexpected Response (9) | Desaturation (411), Laryngospasm (430), Patient Anatomy (576)  Stridor/croup (577), Airway obstruction (570) |
| 11814. Oral Rae endotracheal tube failure | [Provider] tried to intubate with oral Rae ETT but the tube wasn't long enough and didn't pass through vocal cords. There was also a poor [laryngeal] view with a Macintosh 4 blade. | Error in Judgement (17), Patient Positioning (10), Pre-existing Disease (8), Teaching (21) | Difficult intubation, complicated (522), Esophageal intubation (531) |
| 11898. Inability to find medication during intraoperative event | Echo Fellow enters the operating room to give a break and also perform a cardiac ultrasound exam. The patient went into asystole as the surgeon incised [the] pericardium. [The fellow] couldn't find atropine on top of [the] cart. Urgently looks inside cart… couldn't find atropine. Fortunately, [asystole] resolved spontaneously. Eventually [he] does find an atropine box on top of machine but [then] had trouble opening it. Ultimately, [he] does administer atropine. Attending enters the room after event has resolved. [Note: Fellow had been sent to this hospital that day specifically to do cardiac echo exams and hadn’t done cases there in quite some time] | Equipment Usability (1), Logistical or Systems Issues (19), Pre-Existing Disease (8), Patient Unexpected Response (9) | Cardiac Arrest (221), Incorrect time of drug administration (915), Equipment use error (934) |
| 11803. Patient moved during placement of neurosurgical head pins | Patient induced at 19:54… ETT secured. 20:31 Arterial line pressure is 83 systolic and neosynephrine is given. Repeat dose needed to recover blood pressure… Resident confirms ETT placement fiberoptically… At 25:01, neurophysiological monitoring is initiated. Attending leaves at 26:30. At 27:19, resident says [to surgical resident], “you may pin his head but he’s not paralyzed”. Then, noting the low blood pressure, resident turns around and says “just pin him, he need[s] blood pressure”. Surgical resident lowers head, takes frame, and pushes pins in at 28:21. Resident turns on (or up) volatile agent. Patient sits up (literally) with blood pressure 183/115 and heart rate [in the] 90's. [Resident] turns up volatile and gives propofol. | Error in Judgement (17), Inadequate Knowledge (16), Inexperience (14), Patient Unexpected Response (9), Surgical Requirements (5) | Abnormal movement (152), Hypertension, controllable (261), Hypotension, controllable (263), Drug underdose  (914) |

**Table SDC5. Observer Scored and Participant Reported Workload, and Vigilance**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Anesthetic Phase** | **Measure** | **All Cases**  (n=489) | **Non-Routine Event containing Cases**  (n=110) | **Routine (no event) Cases**  (n=379) | **P \*** |
| **Induction** | Observer Scored WKLD | 10.4 ± 1.3 | 10.3 ± 1.1 | 10.4 ± 1.4 | 0.823 |
| Participant Reported WKLD | 11.0 ± 2.1 | 10.8 ± 2.0 | 11.1 ± 2.1 | 0.562 |
| Vigilance Light Response Latency (sec) | 26 (IQR: 11-52) | 29 (IQR: 11-50) | 26 (IQR: 12-53) | 0.755 |
| **Maintenance** | Observer Scored WKLD | 8.4 ± 1.0 | 8.3 ± 1.2 | 8.4 ± 1.0 | 0.920 |
| Participant Reported WKLD | 8.9 ± 1.6 | 9.0 ± 1.7 | 8.8 ± 1.5 | 0.269 |
| Vigilance Light Response Latency (sec) | 24 (IQR: 14-38) | 25 (IQR: 17-37) | 23 (IQR: 14-38) | 0.454 |
| **Emergence** | Observer Scored WKLD | 10.0 ± 1.6 | 9.7 ± 1.8 | 10.1 ± 1.6 | 0.233 |
| Participant Reported WKLD | 10.7 ± 2.4 | 10.4 ± 2.8 | 10.8 ± 2.3 | 0.887 |
| Vigilance Light Response Latency (sec) | 19 (IQR: 9-36) | 18 (IQR: 7-36) | 20 (IQR: 10-36) | 0.303 |

\* Non-Routine Event containing vs. routine (no event) cases univariate comparisons using Wilcoxon test.

**Table legend.** WKLD - Borg workload measured on 1-20 scale (see text for details),