



University of Colorado  
Anschutz Medical Campus



## Use of the EHR to support highly reliable operations

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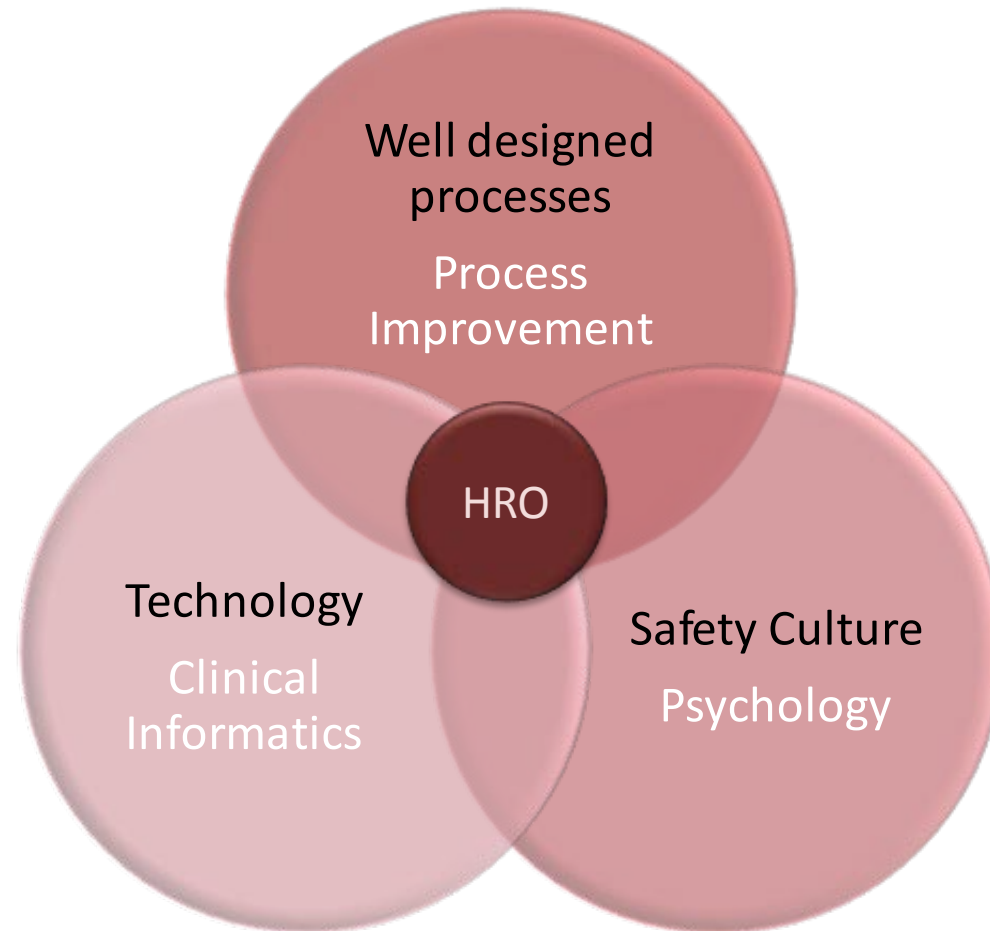
# Highly Reliable Organizations



# Culture of High Reliability

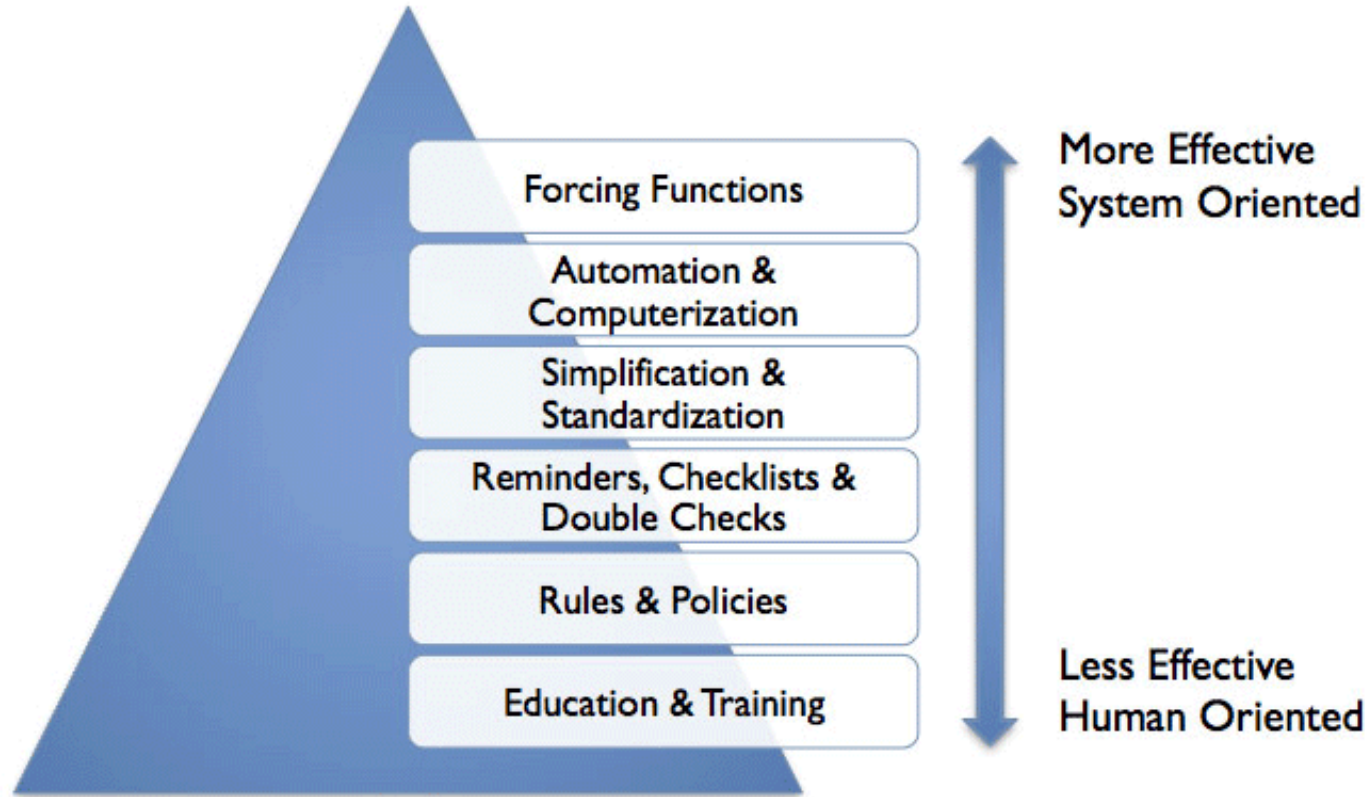


# Highly Reliable Operations



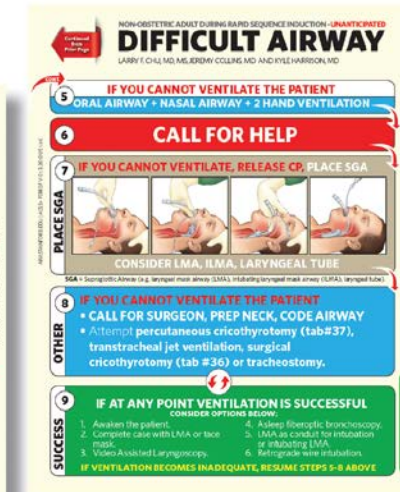
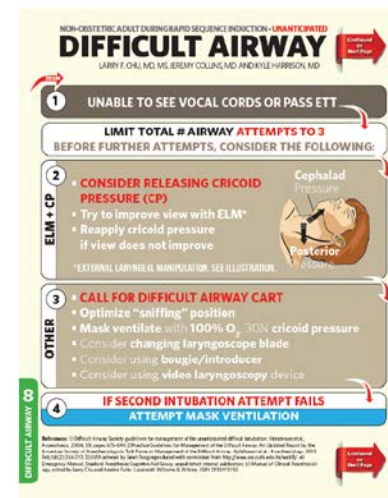
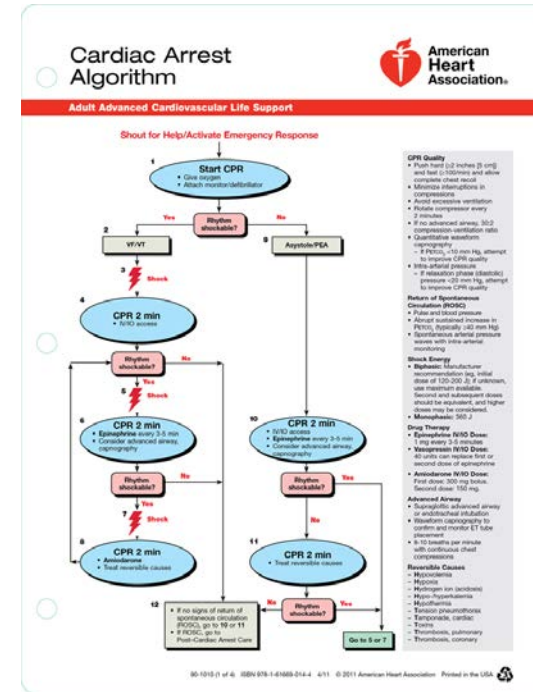
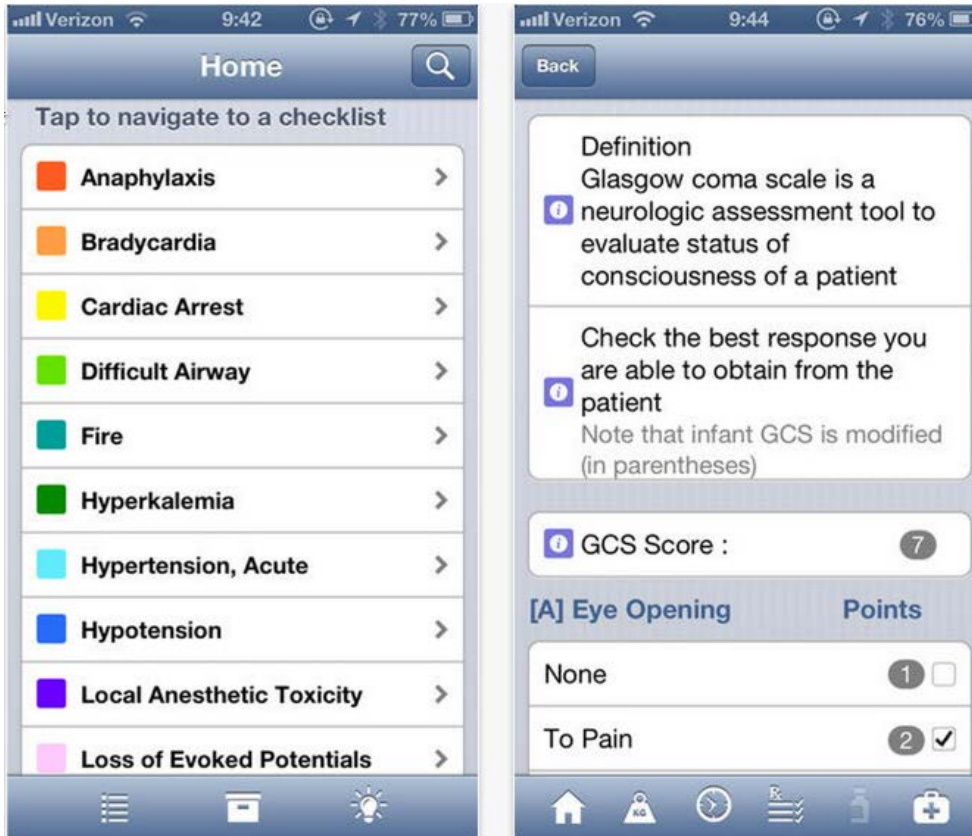


# Hierarchy of Effectiveness



Institute for Safe Medication  
Practices 1999

# Emergency Protocols Cognitive Aids



Checklists courtesy of and designed by Larry Chu, M.D., M.S. and Kyle Harrison, M.D., Stanford Anesthesia Informatics and Media (AIM) Lab. Copyright © Stanford AIM Lab 2014. www.cognitiveaids.org



# iCare Integration with Intra-op

The screenshot displays the iCare software interface for intra-operative care. The main window shows a medication administration table for 9/12/2014, with columns for time (1300, 1330, 1400, 1430, 1500) and a Totals column. Medications listed include fentanyl IV, rocuronium IV, NS, PLASMA-LYTE A, aminocaproic acid, heparin, phenylephrine, calcium chloride, magnesium sulfate, sodium bicarbonate, protamine, and milrinone. A red arrow points to the 'I-Care Emergency' link in the patient information panel on the right.

	1300	1330	1400	1430	1500	Totals
fentanyl IV (mcg)						1200 mcg
rocuronium IV (mg)						150 mg
NS (mL/hr)	←10					50.67 mL
PLASMA-LYTE A (mL)						500 mL
aminocaproic acid (mg/kg/hr)	←11.5				0	4411 mg
heparin (units)						70000 units
phenylephrine (mcg)	80	[160]				560 mcg
calcium chloride (mg)		500	500			1000 mg
magnesium sulfate (mg)		2000				2000 mg
sodium bicarbonate (mEq)						
protamine (mg)			350			350 mg
milrinone (mcg)			2187.5			2188 mcg

**Emergency Management**

- [Malignant Hypertension](#)
- [Anaphylaxis](#)
- [Local Anesthetic Toxicity](#)
- [Hyperkalemia](#)
- [Hypoxemia](#)
- [Hypotension](#)

**Airway Emergencies**

- [Laryngospasm](#)
- [Bronchospasm](#)

**ACLS/PALS**

- [Tachycardia](#)
- [Bradycardia](#)
- [Asystole & PEA](#)
- [Ventricular Tachycardia/Fibrillation](#)

**Vital Signs Graph**

Graph showing LAP (red triangles), LAP Mean (blue crosses), and P1 (orange circles) over time. The y-axis ranges from 0 to 50. The x-axis shows time intervals from 1300 to 1500.



**Events**

- Airway Removed Deep



# iCare Example Reports

## Pulseless Arrest: Ventricular Tachycardia/Fibrillation

<b>Immediately:</b> <ul style="list-style-type: none"> <li>• Inform OR team and call for help</li> <li>• Call for code cart and defibrillator</li> <li>• Discontinue anesthesia and go to 100% O<sub>2</sub></li> </ul>	<p style="text-align: center;">Ventricular Tachycardia</p> 	<p style="text-align: center;">Ventricular Fibrillation</p> 			
<b>Treatment</b> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td data-bbox="338 678 963 892" style="width: 33%; vertical-align: top;"> <b>1) START High Quality CPR</b>            Push Hard (greater than 1/3 AP Chest diameter)            Push Fast (100/min, allow recoil)            Minimize interruptions            Rotate compressor every 2 minutes            Assess quality            (ETCO<sub>2</sub> greater than 10, art diastolic greater than 20)         </td> <td data-bbox="963 678 1587 892" style="width: 33%; vertical-align: top;"> <b>2) Defibrillate</b>            Turn on defibrillator, attach pads            Shock at 106.2 J (2 Joules/kg)            May repeat up to 212.4 J (4 Joules/kg)         </td> <td data-bbox="1587 678 2214 892" style="width: 33%; vertical-align: top;"> <b>3) Prepare Medications</b>  <b>Epinephrine</b>            531 mcg (10 mcg/kg) IV            5.3 mL of 1:10K concentration (0.1 mL / kg)            5.3 mg (0.1 mg/kg) ETT  <b>Amiodarone</b>            265.5 mg (5 mg/kg) IV            (May repeat x 2 for refractory pulseless VF/VT)         </td> </tr> </table>			<b>1) START High Quality CPR</b> Push Hard (greater than 1/3 AP Chest diameter) Push Fast (100/min, allow recoil) Minimize interruptions Rotate compressor every 2 minutes Assess quality (ETCO <sub>2</sub> greater than 10, art diastolic greater than 20)	<b>2) Defibrillate</b> Turn on defibrillator, attach pads Shock at 106.2 J (2 Joules/kg) May repeat up to 212.4 J (4 Joules/kg)	<b>3) Prepare Medications</b> <b>Epinephrine</b> 531 mcg (10 mcg/kg) IV 5.3 mL of 1:10K concentration (0.1 mL / kg) 5.3 mg (0.1 mg/kg) ETT <b>Amiodarone</b> 265.5 mg (5 mg/kg) IV (May repeat x 2 for refractory pulseless VF/VT)
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<b>Management</b> Start CPR => Attach pads => Shock if VFib/VTach => resume CPR 2 min => IV or IO and ETT access => give Epinephrine => cycle every 2 min pulse check, rhythm check, and switch CPR providers q 2 min Go to PEA/Asystole algorithm if rhythm is not shockable					
<b>Treat Reversible Causes</b> <b>H's:</b> Hypovolemia, Hypoxia, Hydrogen Ions (acidosis), Hypoglycemia, Hypo/Hyperkalemia, Hypothermia <b>T's:</b> Tension Pneumothorax, Tamponade (cardiac), Thrombosis (pulmonary and coronary), Toxins					

[Click Here to access additional information and relevant journal articles](#)

Weight used for calculations: 53.1 kg



# Early Warning System



Identify Conditions in which we can intervene  
 Display a warning  
 Advise the clinician how to prevent it

O <sub>2</sub> PRESS	H <sub>2</sub> PRESS	FUEL CELL REAC (R)	FUEL CELL STACK TEMP	FUEL CELL PUMP
CABIN ATM (R)	O <sub>2</sub> HEATER TEMP	MAIN BUS UNDERVOLT	AC VOLTAGE	AC OVERLOAD
FREON LOOP	AV BAY/ CABIN AIR	IMU	FWD RCS (R)	RCS JET
H <sub>2</sub> O LOOP	RGA/ACCEL	AIR DATA (R)	LEFT RCS	RIGHT RCS (R)
—————	LEFT RHC (R)	RIGHT/AFT RHC (R)	LEFT OMS (R)	RIGHT OMS (R)
PAYLOAD WARNING (R)	GPC	FCS SATURATION (R)	OMS KIT	OMS TVC (R)
PAYLOAD CAUTION	PRIMARY C/W	FCS CHANNEL	MPS (R)	—————
BACKUP C/W ALARM (R)	APU TEMP	APU OVERSPEED	APU UNDERSPEED	HYD PRESS





# Early Warning System: *STBUR*

Case Study: Predicting perioperative respiratory adverse events  
STBUR (Snoring, Trouble Breathing, Un-Refreshed Sleep)

Anesthesiologist charted pre-op section

5/20/2014 visit for Hospital Encounter

Pre Intra Post Orders Handoff

Visit Information

- BestPractice
- Procedure Info
- Vitals
- NPO Status
- Airways / Lines

Allergies / Meds

- Allergies
- Potential Interactions
- Outpatient Meds

History

- Problem List
- Prev Anesthesia
- Past STBUR
- History

Evaluation

- STBUR**
- Pre Evaluation
- Ready for Procedure
- Anesthesia Start

Snoring, Trouble Breathing, Un-Refreshed - STBUR Airway Risk Scale

Time taken: 1014 5/22/2014 Show: All Choices

Values By

STBUR Airway Risk Scale

Snore more than half the time?	1=Yes	0=No
Snore loudly?	1=Yes	0=No
Trouble breathing, or struggle to breath?	1=Yes	0=No
Ever stop breathing during the night?	1=Yes	0=No
Wake up feeling un-refreshed?	1=Yes	0=No
Total Score		
Assessment deferred	Urgent/emergent	Parent unavailable

Restore Close F9 Cancel Previous F7 Next F8

Pre Evaluation [click to open](#)

Create Note



# Early Warning System: *Braden Q*

Case study: Braden Q – Risk of pressure ulcer

Nurse entered assessment in the admission encounter

The screenshot displays a software interface for a Braden Q Scale assessment. The interface includes a toolbar with various icons, a search bar for 'Braden Scale', and a table of assessment items. The total score is 10, and the date is 05/20/14.

Item	Score	Last Filed Value
Mobility	1	1
Activity	2	2
Sensory	1	1
Moisture	2	2
Friction/Shear	1	1
Nutrition	2	2
Tissue	1	1
<b>Total Score</b>	<b>10</b>	10 (calculate...)

**Value Information**

**Row Information**

23-28 = No risk or mild risk for skin breakdown. Routine skin assessment and routine skin care completed every shift.  
17-22 = Moderate Risk- see skin care procedure policy for interventions.



# Early Warning System: *Display*

Hyperspace - THE DEVELOPMENT ENVIRONMENT - ANESTHESIOLOGY - CHRIS POPPY

Epic Zztest,Anesthesia Patient Care Case Log Status Board Print Log Out

Responsible Provider: (none) ? Resize

	0600	0630	0700	0730	Totals
propofol (mg)				100	100 mg
OR/ED EBL (mL)					
Urine in mL (mL)					
O2 (L/min)					
N2O (L/min)					
air (L/min)					

Macro Meds Lines Airways Blood Blocks Staff Attest Assess Equip

Zztest, Anesthesia  
<1438141>  
12/03/11  
2 year old Male  
Procedure: INGROWN TOENAIL REMOVAL (Bilateral Toe)  
An Type: general  
ASA: 1 E  
Allergies  
**No Known Allergies**  
 Caution & Warning  
Braden Q, STBUR/OSA  
 I-Care Emergency  
click here  
 Checklist

Report Viewer - Zztest,Anesthesia

Caution & Warning Device Integration Rx Snapshot 3Day MAR Order History Kardex Snapshot Report: Caution & Warning

Zztest, Anesthesia <1438141> Male - 21 month old - 12/03/11 TURBINATE REDUCTION (N/A Nose)

Braden Q	Report	Periop Respiratory Adverse Event Risk
Total Score		Total Score
10 at 09/16 0800		5 at 09/16 0812



# Early Warning System: *Reports*

Braden Q score of 17-22 (Moderate Risk)	Braden Q score of 16 or less (High Risk)
Pad appropriately under <u>all</u> devices	Order Specialty Bed (See specialty bed algorithm / Bed tech: x7-2018)
Offload extremities and bony prominences	Offload extremities and bony prominences
Utilize Gel positioning devices and Z-flos appropriately	Pad appropriately under <u>all</u> devices
Apply Mepilex border dressings over bony prominences for procedures over 2 hrs. (including sacrum)	Utilize Gel positioning devices and Z-flos appropriately
	Apply Mepilex border dressings over bony prominences (including sacrum)

EVIDENCED BASED RECOMMENDATIONS: ASA (2006)	
Anesthesia providers	Nursing
<ul style="list-style-type: none"> <li>Reduce intravenous and oral opioids dosages by 50%</li> </ul>	<ul style="list-style-type: none"> <li>Avoid supine position. Position laterally or with HOB at 30 degrees during recovery.</li> </ul>
<ul style="list-style-type: none"> <li>Consider preoperative initiation of CPAP if high risk</li> </ul>	<ul style="list-style-type: none"> <li>Titrate supplemental oxygen until patient achieves baseline oxygen saturation above 90% on room air in an unstimulated environment.</li> </ul>
<ul style="list-style-type: none"> <li>Consider awake vs. deep extubation after full reversal of NMB's</li> </ul>	<ul style="list-style-type: none"> <li>Alert anesthesiologist or surgeon for concerning respiratory events: Bradypnea &lt;8 resp/min; Apnea &gt;9 seconds; desaturation &lt; 90% while receiving oxygen; inability to wean from nasal cannula; pain sedation score mismatch (high concurrent pain and sedation scores).</li> </ul>
<ul style="list-style-type: none"> <li>Consider regional analgesic techniques rather than systemic opioids</li> </ul>	

**Scoring: Each YES=1 EACH NO=0**  
 Add up score to determine risk of postoperative respiratory adverse events (PRAE):  
 0-2 = no increased risk  
 3-4 = moderate risk (3x's more likely)  
 5 = high risk (10x's more likely)

### EVIDENCED BASED RECOMMENDATIONS: ASA (2006)

Anesthesia providers	Nursing
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# Anesthesia Protocols

Use Epic Anesthesia to standardize provider performance

Pre-op: Review and acknowledge protocol

Intra-op: Use scripting (Macros, Reminders) as cognitive aids

Post-op: Make the performance data available

Self Serve Analytics

## Change Management

Opt-In model vs Department / Service line requirement

Assigned person accountable for cases

Review data with providers





# Protocols

## Intraoperative

---

### **Induction phase:**

- Inhalational vs. IV induction, PIV(send T&C), OETT, bite blocks, OGT, temp probe, tegaderm eyes. **START VANC**

### **Access phase:**

- Two large bore IVs, arterial line, +/- central line, IT morphine

### **Maintenance phase:**

- Start antifibrinolytic
- Total intravenous anesthetic (TIVA) with propofol and remifentanyl or fentanyl infusions
- Consider adding ketamine infusion (0.1-0.4 mg/kg/hr)
- Do not use volatile anesthetics during the maintenance phase, per neuromonitoring request
- Keep MAP within 15% of baseline during exposure/instrumentation, Increase to at least 65 mmHg before correction

### **Emergency phase:**

- D/C ketamine when rods are in
- Prepare for emergence
- Ketorolac (ask surgeon)
- Disposition

### **Transfusion Management:**

- Calculate Estimated Blood Volume (70 ml/kg) and allowable blood loss. Anticipate what EBL will correlate with losing HALF a blood volume, for antibiotic redosing planning
- Have packed RBCs ready in the OR fridge
- Discuss ordering FFP with your attending

[More Information](#)

 [Acknowledge Protocol](#)

[click to open](#)

Acknowledge Protocol - Filed on 12/17/14 at 1541 by Guffey, Patrick J.

# Automatic Macros



Select Macro - Zctest,Anesthesia

Cardiac - Bypass	Cardiac - Non Bypass
Dental General ETT	ENT - Aero
ENT - Bronch	ENT - T & A
ENT - Tymp & Tubes	General - ETT
General - LMA	General - Mask Only
General - Nasal Cannula	MFM Laparoscopic
Neuro - Complex Crani	Neuro - Crani
Neuro - Craniostomy	OB C-Section General
OB C-Section Spinal	OB Labor Epidural
OB Labor to C-Section	Oncology - Mask
Oncology - Nasal Cannula	<b>Ortho - Complex Spine</b>

**Ortho - Complex Spine**

**Grid Medications**

<input checked="" type="checkbox"/> propofol (mg)	<input checked="" type="checkbox"/> fentanyl IV (mcg)	<input checked="" type="checkbox"/> lidocaine 1% IV (mg)
<input checked="" type="checkbox"/> rocuronium IV (mg)	<input checked="" type="checkbox"/> dexamethasone (mg)	<input checked="" type="checkbox"/> morphine IT (mg)
<input checked="" type="checkbox"/> ondansetron (mg)	<input checked="" type="checkbox"/> ketorolac IV (mg)	<input checked="" type="checkbox"/> albumin 5% (mL)
<input checked="" type="checkbox"/> LR (mL)	<input checked="" type="checkbox"/> PLASMA-LYTE A (mL)	<input checked="" type="checkbox"/> propofol (mcg/kg/min)
<input checked="" type="checkbox"/> remifentanyl (mcg/kg/min)		

**Lines/Drains/Airways**  
No lines, drains or airways specified in macro.

**Quick Event Sequence**

<input type="button" value="Replace Existing"/>	Anesthesia Start
<input type="button" value="Add Before Existing"/>	Start Data Collection
<input type="button" value="Add After Existing"/>	Induction
<input type="button" value="Keep Existing"/>	Airway Secured
	A Line Placed
	CV Line Placed
	Regional Block
	Ready for Case
	Airway Removed Deep
	Airway Removed Awake
	Stop Data Collection

**Reminders**

<input checked="" type="checkbox"/> Equipment Reminder Due when Ready for Case is filed.	<input checked="" type="checkbox"/> Assessment Reminder Due when Ready for Case is filed.
<input checked="" type="checkbox"/> Document Staff Due before end of case.	<input checked="" type="checkbox"/> Document Attestations Due before end of case.
<input checked="" type="checkbox"/> Place Post Orders Due when Ready for Case is filed.	<input checked="" type="checkbox"/> Document Airway Due when Airway Secured is filed.
<input checked="" type="checkbox"/> Administer Antibiotic Due when Induction is filed.	<input checked="" type="checkbox"/> Interval Assessment Due 15 minutes from filing Ready for Case. Recurs every 15 minutes until Stop Data Collection is filed.
<input checked="" type="checkbox"/> Document A-Line Due when A-Line Placed is filed.	<input checked="" type="checkbox"/> Document Central Line Due when Central Line Placed is filed.



# Protocols: Reminders



## Reminders

- |  |   |
|--|---|
| <input type="checkbox"/> Equipment Reminder<br>Due when Ready for Case is filed.   | <input type="checkbox"/> Assessment Reminder<br>Due when Ready for Case is filed.   |
| <input type="checkbox"/> Document Attestations<br>Due before end of case.  | <input type="checkbox"/> Place Post Orders<br>Due when Ready for Case is filed.   |
| <input type="checkbox"/> Document Airway<br>Due when Airway Secured is filed.  | <input type="checkbox"/> Administer Antibiotic<br>Due when Induction is filed.  |
| <input checked="" type="checkbox"/> Interval Assessment<br>Due 15 minutes from filing Ready for Case.<br>Recurs every 15 minutes until Stop Data<br>Collection is filed. | <input checked="" type="checkbox"/> Document A-Line<br>Due when A Line Placed is filed.   |
| <input checked="" type="checkbox"/> Document Central Line<br>Due when CV Line Placed is filed.   | <input type="checkbox"/> Document PIV<br>Due when Ready for Case is filed.  |
| <input checked="" type="checkbox"/> Send T&C<br>Due when Induction is filed.   | <input checked="" type="checkbox"/> Administer VANC<br>Due when Airway Secured is filed. Recurs every<br>480 minutes until Anesthesia Handoff Complete<br>is filed.     |
| <input checked="" type="checkbox"/> Bite Blocks<br>Due when Airway Secured is filed.   | <input checked="" type="checkbox"/> APS<br>Due 30 minutes from filing Regional Block.   |
| <input checked="" type="checkbox"/> Call PICU x73239<br>Due 60 minutes from filing Ready for Case.   | <input type="checkbox"/> Document Block Note<br>Due when Regional Block is filed.   |
| <input checked="" type="checkbox"/> Low MAP<br>Due when Correction Start is filed.   | <input checked="" type="checkbox"/> Blood Loss Reminder Monitor<br>Due 1,440 minutes from macro application.  |
| <input checked="" type="checkbox"/> 50% EBV Loss<br>Due 1 minutes from macro application.  | <input checked="" type="checkbox"/> iStat for Hgb/Hct<br>Due 30 minutes from filing Procedure Start.<br>Recurs every 30 minutes until Stop Data<br>Collection is filed. |



# Spine Protocol Results

Implemented Protocol

Manual Process First

Developed electronic decision support

Median length of stay **3.28**

The median post-operative day of discharge **POD 3**





# Preventing Harm: *Anesthesia Sign-In*

Sign-In - Zztest, Anesthesia

AN SIGN-IN REPORT | Device Integration | Rx Snapshot | 3Day MAR | Order History | Kardex | Snapshot | Audit Trail | Anesthesia Review | Anesthesia Snapshot


Report: AN SIGN-IN REPORT

### Anesthesia Sign In - Performed By Anesthesiologist Before Induction in Room

**Anesthesiologist & Circulator Verify:**

- 1) Patient Identification (Two identifiers - first & last name, MRN)**  
Anesthesia Zztest (DOB: 12/3/2011, Sex: male)  
MRN: 1438141  
Check armband and consent  
Verify with family, if applicable
- 2) Procedure and Anesthetic**  
Posterior Spine Fusion: Low Risk-Main Thoracic T-3 T-12 - Back  
Verify on consent  
State anesthetic technique  
Discuss regional block(s) and check for block/surgical site mark(s)  
Blood consent signed, if applicable
- 3) Alerts, Weight and Allergies**  
Alerts:  
Weight: 52.8 kg  
Allergies: Review of patient's allergies indicates no known allergies.
- 4) Assessment scores and prevention strategies, as appropriate**  
For example:
  - ✓ VTE SCDs Sent to OR with Patient: Yes
  - ✓ Total STBUR Score: 0
  - ✓ Braden Q Total Score: 28 - Low or Mild Risk
- 5) Verify information against whiteboard**

In room time: 1649





# Anesthesia Sign-In

Launched with Anesthesia Start automatically

Process Measures – Patient Identification  
6 Sigma (Audited)

Process Measures – Use of the Checklist  
6 Sigma (Audited)

Result - Charting on the Wrong Patient  
5 Sigma (1 event, no use of checklist)

Sign In Process - Highly Reliable Operation



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# IMPROVEMENT

**Sometimes, your questions can be complicated but the answers are simple.**

