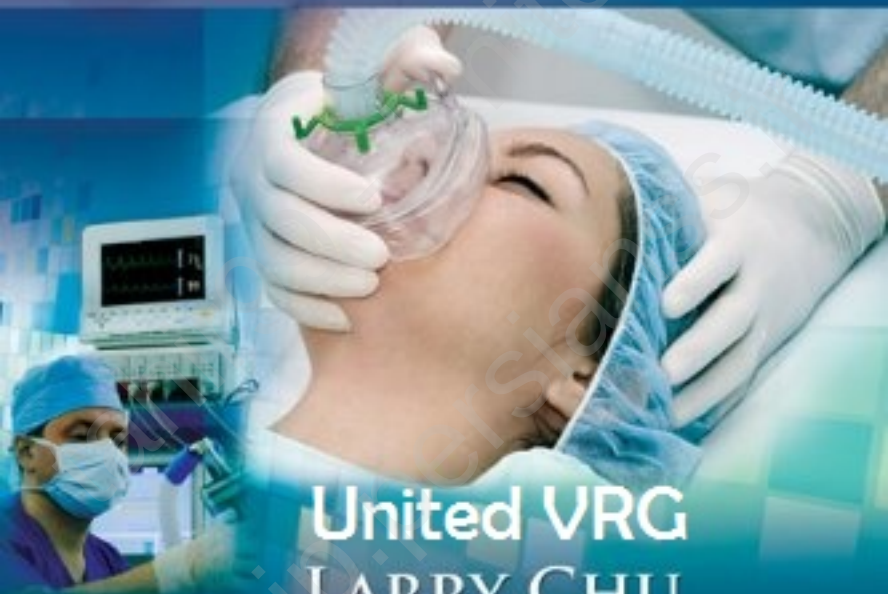


MANUAL OF CLINICAL ANESTHESIOLOGY

FEATURING

Full-color
Point-of-Care Atlases on
TEE, Regional Anesthesia,
& Anesthesia Procedures.
Also including
Crisis Management
Cognitive Aids



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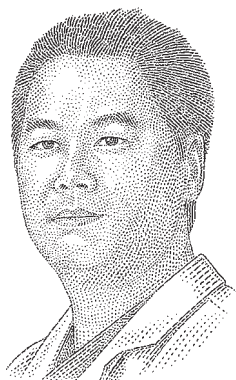
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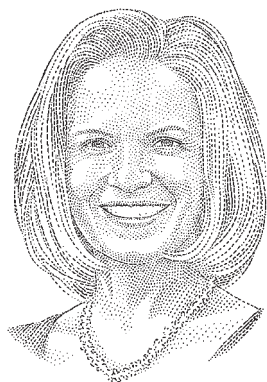
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Preface



Larry F. Chu, MD, MS



Andrea J. Fuller, MD

We designed *Point of Care Essentials* to be used by practicing anesthesiologists during perioperative procedures and treatments. **It is not a textbook of anesthesiology.** There are already many excellent texts that provide detailed explanations of the principles and practice of perioperative medicine. These cards are a companion to the *Manual of Clinical Anesthesiology* and are not intended to be used as a sole source of information about any topic, procedure, or process in anesthesiology.

These cards are a set of **cognitive aids** designed to guide the practitioner through a series of steps necessary to complete a process or procedure. We anticipate that it may be necessary for practitioners who are unfamiliar with certain procedures to reference other anesthesia texts, such as the *Manual of Clinical Anesthesiology*, for additional information.

We have designed these cards to appeal to today's highly visual learners by incorporating full-color graphics, illustrations, and photographs. We believe the spiral-bound and laminated format of *Point of Care Essentials* creates a highly portable reference that brings practical information where it is needed most: in the operating room, on the wards, and at the patient bedside.

Larry F. Chu and Andrea J. Fuller,
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Major portions of this text were developed by the Stanford Anesthesia Informatics and Media Lab, specifically the visual atlases and cognitive aids. We would like to recognize these important contributors to this book.
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1

Insertion of Peripheral IV

By Larry F. Chu, MD, MS

Equipment: Alcohol pad, tourniquet, gauze, 2% lidocaine with 30-g needle, IV catheter, clear dressing, adhesive tape.

Identify anatomy. Hand veins are usually easily visualized, and bifurcation sites on veins can be easier to cannulate. Antecubital veins are usually large and easy to palpate. Explain the procedure to the patient. **Always wear gloves and use universal precautions.**

- A** Apply a tourniquet tightly to the arm. Sterile prep with alcohol.
- B** Place a small local anesthetic wheal proximal to the IV site.



A. A tourniquet is applied tightly to the proximal arm. Loosen the tourniquet if the patient complains of excessive pain. **B.** Insert the 30-gauge needle intradermally and inject a small (0.1 to 0.2 mL) volume of 1% to 2% lidocaine proximal to the planned IV insertion site. It is important not to obscure the IV site with the wheal.

- C** Palpate the vein with one hand and direct the IV with the other.
- D** Stop when a flash of blood is seen. Advance IV 1 to 2 mm further.*



C. Gently palpate the vein with the non-dominant hand. Puncture the skin wheal and advance toward vein. **D.** Stop advancing the catheter when a flash of blood is seen. The needle extends 1 to 2 mm past the catheter tip, so the assembly should be advanced 1 to 2 mm further to ensure the catheter is in the vein.

*The needle assembly should be advanced further for large bore IVs.

PERIPHERAL INTRAVENOUS LINE

- E** Hold the needle assembly with your dominant hand and advance the catheter into the vein in one smooth motion.
- F** Release the tourniquet and prepare to connect the catheter to the IV tubing.



E. Stabilize the needle assembly with your dominant hand and advance the catheter in one smooth motion. A flash of red blood between the catheter and the needle as you advance the catheter into the vein is reassuring. If you feel resistance, do not advance the catheter. **F.** Release the arm tourniquet to minimize bleeding through the catheter when you remove the needle assembly in order to connect the catheter to the IV tubing.

- G** Remove needle assembly. Attach IV tubing to catheter.
- H** Place sterile dressing and secure the IV catheter to the skin with adhesive tape.



G. Remove the needle assembly from the catheter while stabilizing the catheter site. Applying pressure at the end of the catheter can help prevent bleeding from the catheter when the needle is withdrawn. **H.** Attach IV tubing to the catheter and secure the IV with adhesive tape and/or clear adhesive dressing. Additional adhesive tape should be applied to secure the IV to the arm, but is not shown in the photograph so that the IV site can be clearly shown.

Open the IV fluid flow valve to check that free flow to gravity occurs. Suspect an infiltrated IV if the patient complains of pain, fluid does not freely flow to gravity, or if the IV site becomes indurated or swollen.

COGNITIVE AID FOR INDUCTION OF GENERAL ANESTHESIA

2

Standard Induction of General Anesthesia

By Larry F. Chu, MD, MS • T. Kyle Harrison, MD

- M** (Machine checked, High flow O_2).
- S** (Suction on, Yankauer catheter at patient's head).
- M** (Monitors on, NIBP every minute, baseline measurement).
- A** (Airway equipment ready and available).
- I** (IV access and free flow IV with adequate fluid in bag).
- D** (Drugs for induction of anesthesia ready and available).
- S** (Special—extra equipment for case).

- A** Re-check anesthesia machine and OR setup (see MSMAIDS).
- B** Place ASA standard monitors on patient.



A. Check the anesthesia machine, verify high-flow O_2 , suction, airway equipment, drugs according to the MSMAIDS meumonic above. **B.** ASA standard monitors should be used and placement of pulse oximeter probe (avoid index finger as patients can scratch their eyes inadvertently), EKG, NIBP cuff.

- C** Reassure patient and explain induction. Preoxygenate.
- D** Confirm vital signs every minute. **Titrate** induction agent.



C. Reassure patient and explain induction. Preoxygenate with 100% O_2 3 minutes or 8 deep breaths over 60 seconds. **D.** Obtain baseline vitals, and check every 1 minute. Titrate IV induction agent to effect.

INDUCTION OF GENERAL ANESTHESIA

- E** Confirm induction of anesthesia by testing eyelash reflex. Tape eyelids with eye tape.
- F** Confirm ability to mask ventilate patient. Consider insertion of oral or nasal airways to improve mask ventilation.



E. Test eyelash reflex to confirm patient is unconscious. Tape eyelids shut to protect eyes from corneal abrasion during airway manipulation and surgery. **F.** Confirm ability to mask ventilate patient.



**If mask ventilation is not possible, call for help!
Implement ASA Difficult Airway Algorithm.**



G. Administer neuromuscular blocking agent through the IV. **H.** Attach nerve simulator leads to ulnar aspect of the patient's arm and monitor twitches continuously. Mask ventilate patient while awaiting full neuromuscular blockade in order to produce ideal intubation conditions.

- G** Administer neuromuscular blocking agent.
- H** Mask ventilate patient and monitor neuromuscular function. Proceed with intubation when neuromuscular blockade is adequate.

PATIENT CONSIDERATIONS DURING INDUCTION OF GA

1. **Make patient comfortable** (warm room temperature, apply warm blankets when moved to OR table, introduce OR staff).
2. **Reassure patient** during this anxious period of time. Maintain patient modesty by draping body while positioning and applying monitors.

COGNITIVE AID FOR MASK VENTILATION

3

Mask Ventilation

By Larry F. Chu, MD, MS • T. Kyle Harrison, MD

Equipment: Anesthesia machine, airway supplies including oral and or nasal airways, face mask, ventilation system.

Mask ventilation of a patient is a vital skill for anesthesiologists

Mask ventilation allows the anesthesiologist time to safely manage and instrument the airway. **Confirm MSMAIDS mnemonic** (see Induction of Anesthesia cognitive aid).

- A** Preoxygenate patient and induce general anesthesia.
- B** Place nasal part of mask on nose and lever mask down on face.



A. Preoxygenation and induction of anesthesia should proceed as previously described (see Induction of anesthesia cognitive aid) **B.** The nasal aspect of mask is placed on the bridge of the nose and the body of the mask is levered down onto the face, covering the nose and mouth.

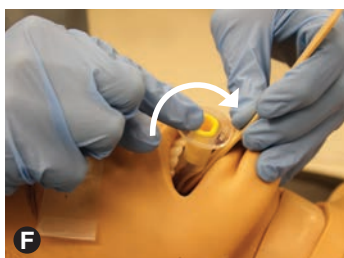
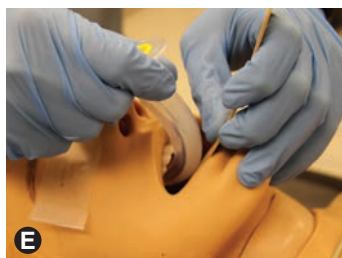
- C** The non-dominant hand thumb and index finger hold the mask.
- D** The remaining fingers pull mandible into mask to open airway.



C. The non-dominant thumb and index finger hold the mask, and can rock gently side to side to achieve the best mask seal. **D.** The remaining fingers pull upward on the mandible to open the airway and ease bag ventilation. The machine pop-off valve (inset) can be rotated to adjust airway pressures if needed.

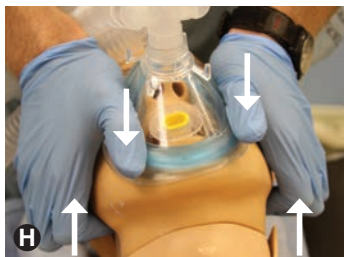
MASK VENTILATION

- E** An oral airway can be inserted to facilitate mask ventilation. Insert the curved tip toward patient's face.
- F** Rotate the airway 180 degrees as it is inserted into the oropharynx.



E. An oral airway can be inserted to open airway structures and ease mask ventilation. The airway is inserted with the curved tip pointing toward the patient's face **F.** The airway is rotated 180 degrees as it is fully inserted into the patient's oropharynx.

- G** A single-handed mask hold with oral airway is a common technique for mask ventilation of patients in the operating room.
- H** If the single-handed method is inadequate, institute the two-handed mask technique. Place both hands on the mask, thumbs opposite the mask connector. Create firm mask seal with jaw-thrust and chin-lift maneuvers.



G. Single-handed mask hold with oral airway. **H.** A two-handed mask technique can be employed if difficult mask ventilation is encountered using the single-handed mask hold technique. The metacarpophalangeal (MCP) joints of both thumbs are placed opposite the mask connector. This allows four fingers to create a firm mask seal, while maintaining jaw-thrust and chin-lift maneuvers. This position can be maintained comfortably for prolonged ventilation.



**If mask ventilation is not possible, call for help!
Implement ASA Difficult Airway Algorithm.**

COGNITIVE AID FOR LMA INSERTION

4

Laryngeal Mask Airway Insertion

By Larry F. Chu, MD, MS • T. Kyle Harrison, MD

Equipment: Laryngeal mask airway, 30 cc air syringe, lubricant, adhesive tape, airway management equipment including face mask, and oral airways.

Confirm MSMAIDS mnemonic (see Induction of Anesthesia cognitive aid).

- A** Assemble equipment, deflate LMA cuff with air syringe.
- B** Lubricate LMA cuff.



A. Assemble the components necessary for LMA insertion. Deflate the LMA cuff according to the manufacturer's guidelines so that the leading edge is smooth **B.** Lubricate the LMA with lubricant, such as lidocaine ointment.

- C** Explain the procedure and reassure patient. Induce general anesthesia (see Induction of anesthesia cognitive aid). Place patient in "sniffing" position.
- D** Open mouth with "scissor" technique using non-dominant hand.



C. Explain procedure and induce general anesthesia. Neuromuscular blockade is usually unnecessary for LMA insertion. Place patient in proper "sniffing" position. **D.** Tilt the patient's head backward (caution in patients with uncleared c-spine injuries) or open mouth with "scissor" technique.

LARYNGEAL MASK AIRWAY INSERTION

- E** Grasp LMA in dominant hand. Flat side of the cuff should face patient's head. Place first finger in space between tube and cuff.
- F** The leading edge of the cuff should be flat and pressed upward against the hard palate during insertion. Guide LMA above tongue and down oropharynx in a smooth continuous motion.



E. Grasp the LMA in your dominant hand with the curved tube and flat side of cuff facing the patient. Place your index finger in the space between the tube and the LMA cuff. **F.** Insert the LMA into the mouth and press the cuff upward against the hard palate. Guide the cuff above the tongue and down the oropharynx in a smooth motion. Inadequate anesthesia may cause difficulty with insertion of the LMA.

- G** Stop when resistance is met (7 to 10 cm of LMA should protrude).
- H** Inflate cuff with approximately 30 cc air. The LMA may slide out of the mouth 1 to 2 cm during inflation. This is normal.

Confirm proper placement of the LMA with bilateral auscultation of breath sounds and capnography. The neck should be auscultated and air leakage should not be heard below 20 cm H₂O, indicating proper positioning of the device. Secure the LMA with adhesive tape.



G. Stop advancing LMA when resistance is met. Inflate the cuff with about 30 cc air. The LMA may slide out of the mouth 1 to 2 cm, which is normal. **H.** Confirm proper placement by auscultation and capnography. A leak pressure should be assessed by insufflating 20 cm H₂O of air pressure through LMA. No air leakage at the patient's neck should be observed.

COGNITIVE AID FOR INTUBATION

5

Endotracheal Intubation

By Larry F. Chu, MD, MS • T. Kyle Harrison, MD

Equipment: Endotracheal tube (ETT), stylet, air syringe, stethoscope, bag mask ventilation device, adhesive tape.

Confirm MSMAIDS mnemonic (see Induction of Anesthesia cognitive aid).

- A** Assemble equipment for airway manipulation and intubation.
- B** Explain procedure and reassure patient. Induce general anesthesia (see Induction of anesthesia cognitive aid). Place patient in “sniffing” position.



A. Assemble the airway equipment needed for endotracheal intubation, including an ETT, stylet, laryngoscope and Macintosh 3 blade. **B.** Place the patient in the “sniffing” position after induction of anesthesia and establishing optimal neuromuscular blockade and intubating conditions.

- C** Use right thumb and third finger to “scissor” open mouth widely.
- D** Insert laryngoscope sweeping tongue aside from right to left.



C. Use the right hand to scissor open the mouth with thumb and third finger **D.** Insert the Macintosh laryngoscope blade into the mouth, sweeping the tongue to the side (right to left).

ENDOTRACHEAL INTUBATION

- E** Advance laryngoscope blade into the airway. Lift in an upward and forward motion toward the corner of the room.
- F** Once VCs are visualized, advance ETT through glottic opening. Stop advancing when ETT cuff is past the VCs.



E. Advance the laryngoscope blade into the airway and gently lift in an upward and forward motion. Do not tilt the laryngoscope backward and do not use excessive force. Be careful to avoid dental damage during laryngoscopy. Beginners often do not advance the blade far enough into the Vallecula. Cricoid pressure can assist airway visualization
F. Once the vocal cords (VC) are visualized, do not take your eyes off glottic opening—have an assistant hand you the ETT. Advance ETT through glottic opening. Stop when cuff is past VCs.

- G** Inflate the ETT with 2 to 6 cc air to achieve 20 cm H₂O pressure.
- H** Attach anesthesia circuit to airway connector at end of ETT.

Proper placement should be confirmed by capnography and bilateral auscultation of breath sounds on lung examination.
Secure the ETT with adhesive tape.



G. Remove ETT stylet. Inflate the ETT cuff with 2 to 6 cc air (cuff pressure can be measured and adjusted to a minimum 20 cm H₂O) **H.** Attach anesthesia circuit to the airway connector at the end of the ETT. Confirm proper placement of the ETT by capnography and auscultation of bilateral breath sounds.

6

Awake Fiber Optic Intubation

By Larry F. Chu, MD, MS • T. Kyle Harrison, MD

Equipment: Airway topicalization supplies, including 4% lidocaine solution. Fiberoptic bronchoscope (FOB), endotracheal tube (ETT), air syringe, and McGill forceps.

Confirm MSMAIDS mnemonic (see Induction of Anesthesia cognitive aid). An assistant should be available throughout procedure.

- A** Assemble equipment for airway anesthesia and intubation.
- B** Explain procedure and reassure patient. Sedate as appropriate. Administer nebulized lidocaine. Consider antisialagogue.



A. Assemble equipment including 4% lidocaine solution, topicalization devices such as spray wand or nebulizer, oral airway, ETT and air syringe. **B.** Nebulized lidocaine is an effective method for topical anesthesia of the airway to tolerate awake fiberoptic intubation (FOI). **Ensure total topical lidocaine does not exceed maximum dose of 5 mg/kg.** Consider 0.2 mg IV glycopyrrolate antisialagogue.

- C** Lidocaine should also be applied directly to the airway.
- D** Insert an oral airway. The patient should not react or “gag.”



C. Lidocaine should also directly to the airway with a spray wand. **D.** Test adequate airway topicalization by placing oral airway with lidocaine ointment. The patient should not react or “gag.”

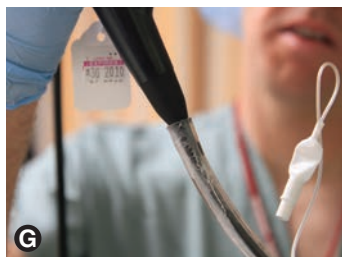
AWAKE FIBEROPTIC INTUBATION

- E** Test the fiberoptic broncho scope (FOB) to ensure that it is functioning properly.
- F** Remove the airway connector from the end of an ETT and apply lidocaine ointment for lubrication.



E. Assemble and test the FOB according to the manufacturer's instructions. **F.** Remove the airway connector from the end of an ETT and apply a small amount of lidocaine ointment for lubrication so the ETT will glide smoothly over the FOB.

- G** Slide lubricated ETT over the FOB. Remove any excess ointment from the FOB. Consider applying anti-fog spray to FOB.
- H** Elevate the head of the bed. Adjust bed height for easy positioning.



G. Slide the lubricated ETT over the FOB. Remove any excess ointment from the end of the FOB. Consider applying anti-fog spray or liquid to the end of the FOB. **H.** For awake FOI, stand in front of the patient and place video monitor within easy viewing distance. Elevate the head of the patient's bed 45 degrees.

IMPORTANT TASKS DURING FOI

1. An assistant should be present to **continuously monitor** the patient's vital signs during FOI. **Help should be immediately available.**
2. An assistant can titrate sedation, as appropriate during the procedure, under the direction of an anesthesiologist. **AVOID APNEA.**
3. Patient should **breathe spontaneously at all times** during the awake FOI procedure.

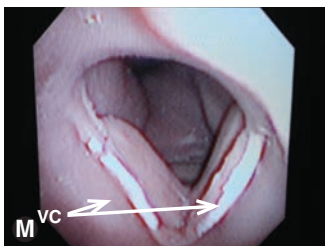
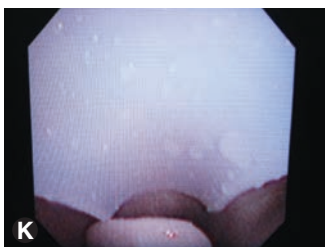
COGNITIVE AID FOR AWAKE FOI

- I** Insert the tip of the FOB through the airway into the mouth.
- J** Look through the eyepiece or video monitor of the FOB.



I. Insert tip of the FOB through the airway. **J.** Once the FOB is inserted, focus your attention on the video monitor (or FOB eyepiece) to visualize the airway structures as you advance the FOB.

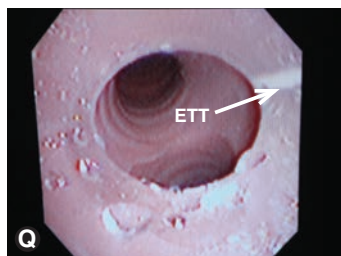
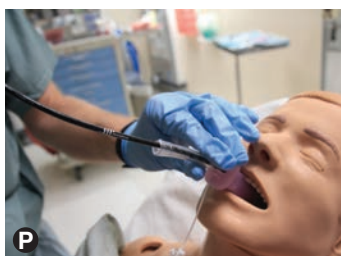
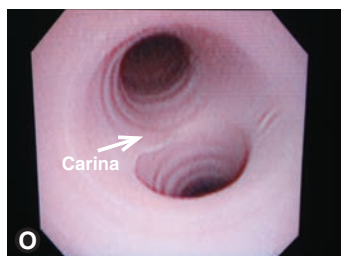
- K** Tip of airway and patient's soft palate will come into view as the FOB is advanced into the airway.
- L** Anteflex (or flex) the tip of the FOB and advance until epiglottis and vocal cords (VCs) come into view.
- M** Advance through cords.
- N** Advance the scope past the vocal cords.



K. The tip of the airway and soft palate come into view. **L.** Gently anteflex the tip to assist visualization of the glottis or epiglottis. You may occasionally need to flex (thumb up) to assist visualization **M.** Advance the FOB under the epiglottis, rotating the scope or flexing the tip to keep the VCs in the middle of the screen. **N.** Advance the scope past the VCs.

AWAKE FIBEROPTIC INTUBATION

- O** Advance to mid-trachea.
- P** Advance ETT over FOB into airway in a smooth motion.
- Q** Confirm placement as FOB is withdrawn from airway.
- R** Remove FOB from the airway
- S** Secure ETT with McGill forceps while oral airway is removed over the ETT.
- T** Reattach airway connector to ETT. Inflate the ETT cuff and re-confirm position by auscultation and capnography.



O. Advance FOB until the carina is visualized and stop. **P.** Advance the ETT over the FOB into the airway. If difficulty is encountered, grasp the ETT and rotate 90 degrees counter clockwise to minimize impingement behind arytenoid. **Q.** Confirm proper ETT placement above carina as FOB is withdrawn **R.** Remove FOB from ETT. **S.** Grasp ETT with McGill forceps as the oral airway is removed. **T.** Reattach airway connector to ETT. The cuff is inflated and position is confirmed by presence of exhaled CO₂ gas by capnography and auscultation of bilateral breath sounds.

7

Insertion of Left-Sided Double Lumen Tube

By Larry F. Chu, MD, MS • Vivekanand Kulkarni, MD, PhD •
T. Kyle Harrison, MD

Equipment: Appropriately sized double lumen tube (DLT), clamp, fiberoptic bronchoscope, laryngoscope, stethoscope, and standard airway management equipment (see Intubation and Mask Ventilation cognitive aids).

Confirm MSMAIDS mnemonic (see Induction of Anesthesia cognitive aid).

- A** Assemble equipment for airway instrumentation and intubation.
- B** Explain procedure and reassure patient. Induce general anesthesia (see Induction cognitive aid). Place patient in “sniffing” position.



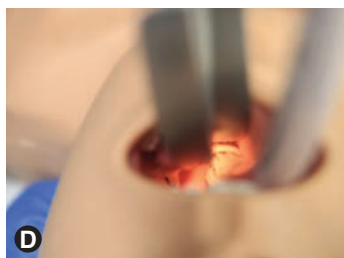
A. Assemble equipment including appropriately sized DLT (Table 7-1) **B.** Explain the procedure to the patient. Confirm MSMAIDS mnemonic. After confirming normal stable vital signs, proceed with induction (see Induction of Anesthesia cognitive aid). Place the patient in the proper “sniffing position.”

Table 7-1**Guidelines for Left-Double Lumen Tube Selection**

Tracheal Width (mm)	Recommended Size
>18	41 Fr (M,R,S,P)
>17	41 Fr (M,S) 39 Fr (R,P)
>16	39 Fr (MS) 37 Fr (R,P)
>15.5	37 Fr (MS) 35 Fr (R,P)
>15	35 Fr (M,RS,P)
>14	32 Fr (M)
>13	32 Fr (M)
>12	28 Fr (M)
>11	26 Fr (R)

Manufacturer: M, Mallinckrodt (St. Louis, MO); P, Portex (Keene, NH); R, Rusch (Duluth, GA); S, Sheridan (Argyle, NY).

- C** Perform direct laryngoscopy under ideal intubating conditions.
- D** Advance DLT into the airway. Stop when blue cuff passes vocal cords.



C. Perform direct laryngoscopy to visualize the glottic opening under optimized intubating conditions. **D.** Advance the DLT under direct visualization into the airway and stop advancing the DLT when the blue bronchial cuff passes the vocal cords. The tracheal (clear) cuff should be above the vocal cords.

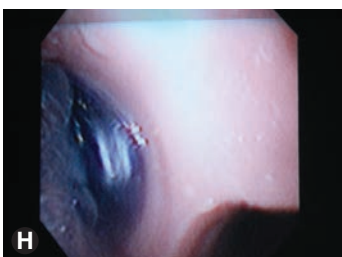
INSERTION OF LEFT-SIDED DOUBLE LUMEN ETT

- E** Remove stylet from the DLT. Rotate DLT 90 degrees counterclockwise and advance with a smooth motion into the airway.
- F** Attach connectors to end of bronchial (blue) and tracheal (clear) lumens.



E. Remove stylet from DLT. Rotate DLT 90 degrees counterclockwise as you advance the tracheal cuff through the DLT. This will help direct the end of the DLT with the bronchial cuff into the left mainstem bronchus. **F.** When the tube is inserted to a depth of 29 cm at the lips, attach the tracheal and bronchial lumens to the airway connectors.

- G** Confirm proper placement by auscultation.
- H** Confirm proper placement by fiberoptic bronchoscope (FOB) through tracheal lumen.



G. Inflate both tracheal and bronchial cuffs and auscultate bilateral breath sounds. Occlude bronchial lumen and auscultate right-side only breath sounds. Occlude tracheal lumen and auscultate left-side only breath sounds, confirming placement. **H.** Insert FOB through tracheal lumen and visualize only the rim of the blue cuff in the left main bronchus, just beyond the carina, confirming proper placement. If the blue cuff herniates across the carina it is shallow and needs to be advanced until only the blue rim is visible

COGNITIVE AID FOR CRICHTHYROIDOTOMY

8

Wire Cricothyroidotomy

By Larry F. Chu, MD, MS • Pedro P. Tanaka, MD, PhD

Equipment: Cricothyroidotomy kit including aspiration needle and syringe, wire, scalpel, dilator, and cannula.

Call for help: Call for surgeon capable of performing emergency tracheotomy and have tracheotomy tray immediately available.

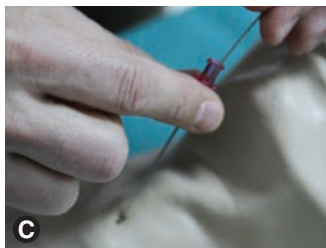
Sterile prep the patient's neck. Wear sterile gown, face mask and sterile gloves (*photographs do not show gloves but they should be worn*).

- A** Puncture cricothyroid membrane (CTM) with a needle attached to a 5 mL syringe.
- B** Confirm tracheal entry by aspirating air into the syringe.



A. The cricothyroid membrane is identified by palpation and is located between the thyroid cartilage and cricoid cartilage. **B.** Insert the aspiration needle through the cartilage and direct 45 degrees caudad while aspirating the saline-filled syringe for the presence of air bubbles. Stop advancing the needle when air is aspirated in the syringe. The needle is now in the trachea.

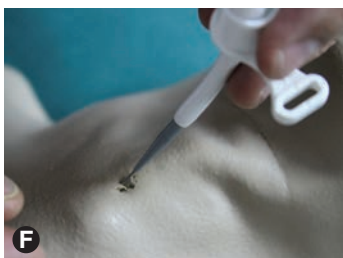
- C** Insert wire through the needle and remove the needle.
- D** Make a stab incision caudally with a scalpel.



C. Insert the soft (pliable) end of the wire through the needle 3 to 5 cm. **D.** Make a small incision in the skin/cricothyroid membrane holding the scalpel in the caudal direction.

WIRE CRICOTHYROIDOTOMY

- E** Assemble the dilator/cannula.
- F** Pass the assembly device over the wire into the trachea in a smooth motion.



E. Assemble the dilator/cannula by placing the pointed introducer into the cannula. **F.** Pass the wire through the introducer and advance the assembly into the airway over the wire in a smooth motion.

Ensure the dilator is fully and completely seated inside the airway. Advance the assembly with moderate force over wire through the skin and into the airway.

- G** Remove the wire and introducer.
- H** Attach self inflating bag or circuit and ventilate the patient.



G. Ensure the introducer/assembly is completely seated inside the airway. Remove the dilator and the wire from the airway. **H.** Attach a self-inflating bag or circuit to the airway device and ventilate the patient.

Confirm ventilation with auscultation of the lung fields and change of color on a CO₂ indicator device.

Secure the airway device to the patient's neck.

9

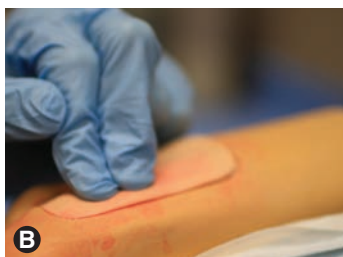
Radial Artery Catheterization

By Larry F. Chu, MD, MS • T. Kyle Harrison, MD

Equipment: Radial artery catheter, gauze, alcohol pad, suture material, adhesive dressing, and tape.

Explain the procedure to the patient and obtain consent. **Always wear gloves and use universal precautions.**

- A** Place the wrist in extension as shown. Wrist splints can assist with proper positioning.
- B** Palpate the radial artery pulse using the fingertips of your non-dominant hand.



A. Place the wrist in extension as shown. The use of wrist splints can assist with proper positioning during placement. The splint may be removed after placement is accomplished **B.** Palpate the radial artery pulse located 1 to 2 cm from the wrist, between the bony head of the distal radius and the flexor carpi radialis tendon.

- C** Clean the wrist with alcohol to sterilize the catheter insertion site.
- D** Insert the needle/catheter assembly at a 45 degree angle over the site of arterial pulsation.



C. Clean the insertion site with alcohol prep. **D.** Insert the needle/catheter assembly into the wrist at the site of arterial pulsation.

RADIAL ARTERY CATHETERIZATION

- E** Advance the needle/catheter assembly slowly toward arterial pulse. Stop once arterial blood is observed in the assembly barrel.
- F** Advance the guide wire by sliding the black tab on the barrel down toward the catheter. Stop if resistance is encountered.



E. Advance the needle/catheter assembly slowly toward the arterial pulsations until a flash of blood is visualized. Stop advancing assembly. **F.** Free flow of arterial blood indicates proper needle placement. Advance guide wire into artery by sliding the black tab down the barrel of the assembly. Do not advance wire if resistance is encountered. Smooth and easy guide wire advancement is reassuring.

- G** Apply downward pressure on the radial artery at the catheter tip. Remove the needle/wire assembly.
- H** Attach arterial pressure transducer tubing to the catheter and secure the catheter with sutures to the patient's wrist. Alternatively transparent adhesive dressing and tape can be used.



G. Apply pressure to the artery at the catheter tip and remove the needle/wire assembly. **H.** Attach arterial pressure transducer tubing to the catheter and secure the catheter with sutures or an adhesive dressing. Confirm proper placement by evaluating arterial pressure waveform on the patient monitors.

Confirm proper placement by evaluating the arterial pressure waveform on the patient monitors.

10

Central Venous Catheterization

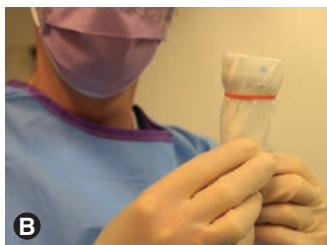
By Larry F. Chu, MD, MS • T. Kyle Harrison, MD

Equipment: Central line kit and full body sterile drape. Ultrasound machine and probe with sterile transducer sheath.

Wear sterile gown, face mask, and sterile gloves. Explain procedure to patient.

Always wear gloves and use universal precautions.

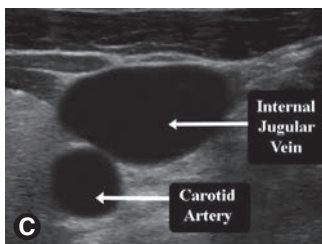
- A** Sterile prep the patient's neck. Trendelenberg if possible.
- B** Place gel on ultrasound (US) probe. Place probe into sterile sheath.



A. If needed and appropriate, Trendelenberg position (head down) can be used to increase venous return to the heart and facilitate central venous cannulation. The neck should be sterile prepped with alcohol. **B.** Ultrasound gel should be placed on the probe and covered with a sterile sheath by an assistant.

C Sterile drape neck (not shown). Place the US probe parallel and cephalad to the clavicle between the two heads of the sternocleidomastoid muscle. The internal jugular vein is visualized.

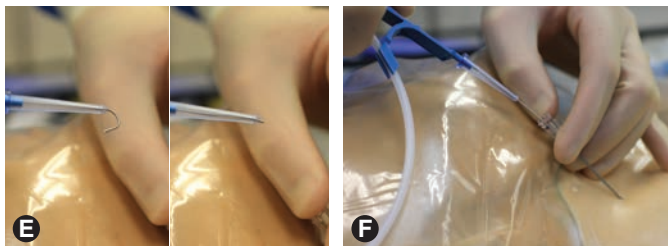
D Puncture the skin at a 45 degree angle and aspirate until the needle is seen on US and a flash of blood is aspirated into syringe.



C. The internal jugular vein is easily compressible while the common carotid artery is pulsatile and not compressible. **D.** Advance needle at a 45 degree angle and aspirate needle until blood is aspirated. Stop.

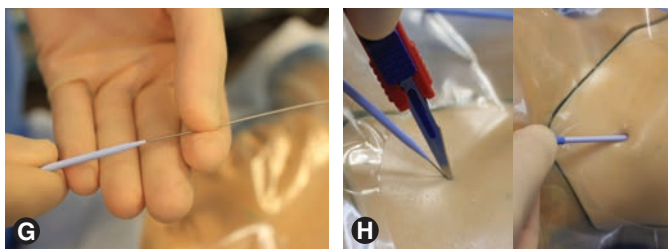
CENTRAL VENOUS CATHETERIZATION

- E** Prepare wire by retracting the soft tip into the holder.
- F** Confirm free flow blood and advance the wire through the needle. Monitor EKG. If ventricular ectopy is observed, stop and retract wire.



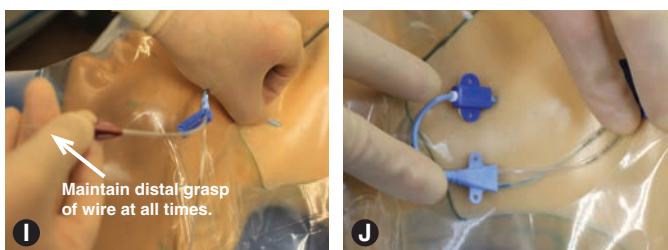
E. Retract wire into the holder. **F.** Confirm free flow venous blood and pass the wire through the needle in a smooth motion. Monitor EKG. If ventricular ectopy is observed, stop and retract wire.

- G** Advance dilator over wire.
- H** Nick skin and advance dilator.



G. Advance dilator over wire, retaining control of wire at all times. **H.** Create a small skin incision at insertion site and advance dilator in a smooth motion. Remove dilator, retaining control of wire.

- I** Remove dilator, advance catheter over wire.
- J** Suture catheter.



I. Advance catheter over wire, grasp wire as it exits catheter. Retract wire from catheter. **J.** Flush lumens of catheter with saline. Secure the catheter with sutures and a dressing.

11

Spinal Anesthesia

Larry F. Chu, MD, MS • Andrea J. Fuller, MD •
T. Kyle Harrison, MD

Equipment: Spinal anesthesia kit, sterile gloves, mask, and hat.

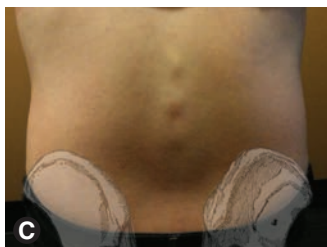
ASA Standard Monitors should be placed prior to spinal placement. An assistant should be available throughout procedure.

- A** Assemble equipment for spinal placement.
- B** Explain procedure and reassure patient. Sedation as appropriate. Patient positioning is critical for successful placement. Instruct the patient to round his/her back to facilitate spinal placement.



A. Assemble equipment for spinal anesthesia including spinal medications and local anesthetic for skin wheal. **B.** The patient should be instructed to sit with his/her back rounded in order to open the spaces between the spinous processes to facilitate placement of spinal anesthesia.

- C** Examine surface anatomy of the patient's back. Identify the spinous processes on the top of the iliac crests (L4 spinous process).
- D** Sterile prep the back widely around the L4-5 interspace.



C. The surface anatomy of the back can be examined for spinous process landmarks. The superior margin of the iliac crests can be palpated and represent the approximate level of the L4 spinous process. **D.** Sterile prep the back with sterile prep solution widely around the L3-4 or L4-5 interspace.

SPINAL ANESTHESIA

E Drape patient. With sterile technique, reconfirm landmarks for lumbar interspace.

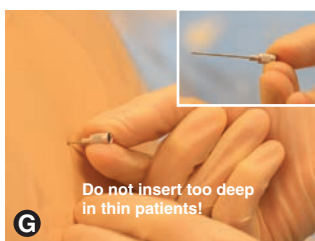
F Place a skin wheal of local anesthetic. Infiltrate deeper.



E. Drape the patient and reconfirm L3-4 or L4-5 level. **F.** Inject local anesthetic skin wheal and then redirect the needle through the wheal to infiltrate deeper tissues along the intended spinal needle path.

G Insert introducer needle perpendicular to back, midline.

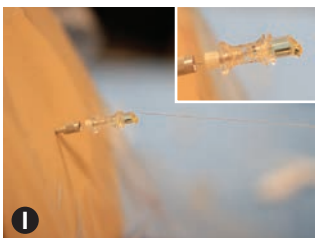
H Insert spinal needle through introducer until “pop” is felt.



G. Place the introducer perpendicular to the back, midline at L3-4 or L4-5. **H.** Advance the spinal needle until a “pop” is felt, indicating dural puncture. Stop advancing the needle immediately.

I Remove stylet. Observe free flow cerebrospinal fluid (CSF).

J Slowly inject spinal medication.



I. Remove the stylet from the spinal needle. Observe free flow CSF fluid, noting absence of blood. **J.** Attach syringe with spinal medications. Aspirate slightly to reconfirm CSF flow, then inject medication while stabilizing needle at the introducer. Aspirate at the end to reconfirm the full dose was administered.

12

Lumbar Epidural Placement

Larry F. Chu, MD, MS • Andrea J. Fuller, MD •
T. Kyle Harrison, MD

Equipment: Epidural catheterization kit, sterile gloves, mask, and hat.

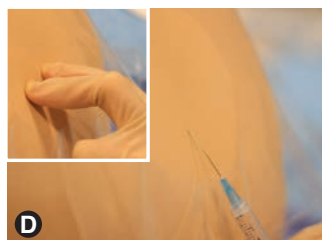
ASA Standard Monitors should be placed prior to epidural placement. An assistant should be available throughout procedure.

- A** Assemble equipment for epidural placement.
Explain procedure and reassure patient. Sedation as appropriate.
- B** Patient positioning is critical for successful placement. Instruct the patient to round his/her back to facilitate epidural placement.



A. Assemble equipment for epidural including saline for loss of resistance syringe and local anesthetic for skin wheal. **B.** The patient should be instructed to sit with his/her back rounded in order to open the spaces between the spinous processes to facilitate epidural catheter placement.

- C** The back should be sterile prepped widely around L4-5 interspace.
- D** Place sterile drape. With sterile technique, palpate L4 spinous process (level of iliac crests). Inject local anesthetic wheal in the interspace.

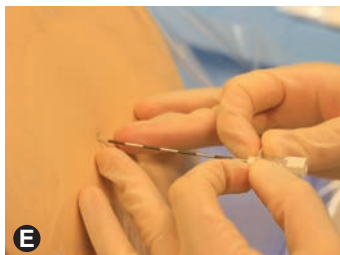


C. The back should be widely sterile prepped with sterile prep solution. **D.** The L4 spinous process should be palpated (level with the top of the iliac crests) and a small local anesthetic wheal injected in the L4-5 interspace. Local anesthetic can be infiltrated deeper through the skin wheal. 2% lidocaine can be used.

LUMBAR EPIDURAL CATHETER PLACEMENT

E The Tuohy epidural needle should be inserted midline.

F Once the Tuohy is seated into interspinous ligament (1 to 2 cm), remove stylet.



E. The Tuohy needle should be inserted perpendicular to the back, midline, through the L4-5 interspace. **F.** Once the Tuohy needle has passed subcutaneous tissues and is firmly seated in ligament (a “crunching” sensation is felt), the stylet can be removed.

G A saline-filled loss of resistance (LOR) syringe should be attached to the Tuohy needle.

Apply gentle constant pressure to the plunger as the Tuohy needle is advanced through ligament by the non-dominant hand.

H As ligamentum flavum is encountered an increase in resistance may be felt, followed by a sudden LOR. Stop.



G. A saline-filled loss of resistance syringe should be attached to the Tuohy and slowly advanced while constant gentle pressure is applied to the plunger. **H.** Resistance to the plunger will suddenly decrease when the epidural space is entered (loss of resistance, LOR). Stop. Note the depth of LOR.

PATIENT CONSIDERATIONS DURING EPIDURAL PLACEMENT

1. **Make patient comfortable** (warm room temperature, apply warm blankets when moved to OR table, introduce OR staff).
2. **Reassure patient** during this anxious period of time. Maintain patient modesty by draping body while positioning and applying monitors.

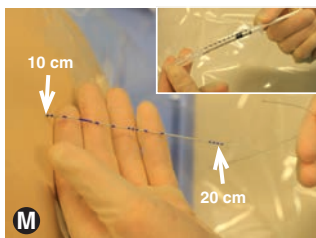
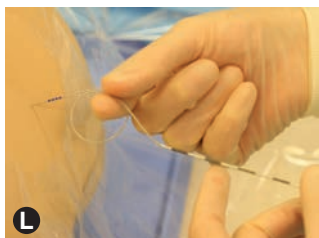
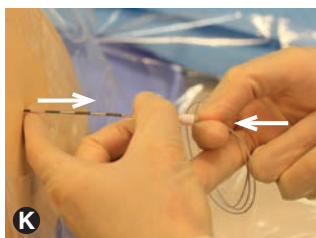
COGNITIVE AID FOR EPIDURAL

- I** Place catheter into Tuohy needle. (For CSE, first do Steps **O** to **T**.)
- J** The catheter should advance smoothly into the epidural space.



I. Epidural catheter is placed into Tuohy. **J.** The catheter should advance smoothly into the epidural space. If resistance is felt, consider dilating the epidural space with saline or repeating LOR technique.

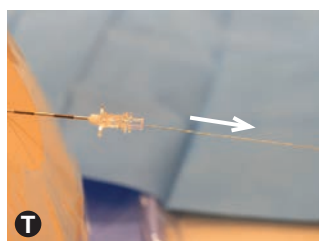
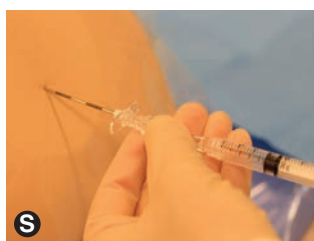
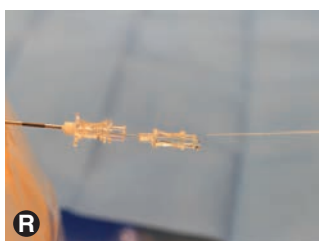
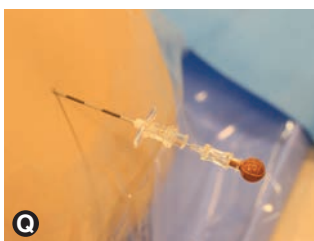
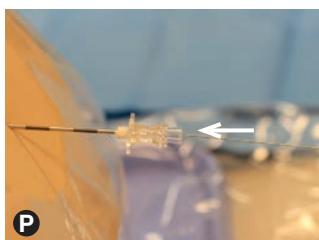
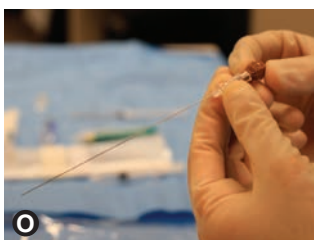
- K** The needle can be removed after 15 to 20 cm has been threaded into the epidural space. Provide counter-traction on catheter.
- L** Once needle has been removed, pull the catheter out until 5 cm remains in the epidural space.
- M** Aspirate the catheter.
- N** Cap/label catheter.



K. The Tuohy needle is removed with counter-traction on the catheter to prevent catheter migration during needle removal. **L.** Once the needle is removed, pull the catheter out until 5 cm remains in the epidural space. **M.** Aspirate the catheter with a 1 cc syringe to confirm absence of cerebrospinal fluid (CSF) (intrathecal) or blood (intravascular). **N.** Place a cap and label on the end of the catheter.

COMBINED SPINAL EPIDURAL

- E** Place a Tuohy needle into the epidural space (Steps A-E).
- O** Prepare spinal needle (SN).
- P** Insert SN through Tuohy needle until a “pop” is felt
- Q** Remove stylet.
- R** Observe CSF flow.
- S** Aspirate CSF, then slowly inject spinal medication.
- T** Remove SN.
- G** Go to Steps K–N.



O. Prepare a 26-27 pencil point spinal needle (SN) by loosening the stylet. **P.** Advance the SN through the Tuohy from Step **E**. **Q.** Continue to advance the SN until a “pop” is felt, at which point stop advancing the needle. **R.** Remove the stylet from the SN and observe free flow CSF to gravity. **S.** Stabilize Tuohy needle and attach a syringe containing spinal medications (Luer lock preferable), being careful not to inadvertently reposition the SN. Gently inject the spinal medication through the SN. **T.** Remove SN from the Tuohy needle.

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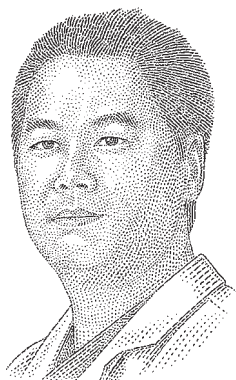
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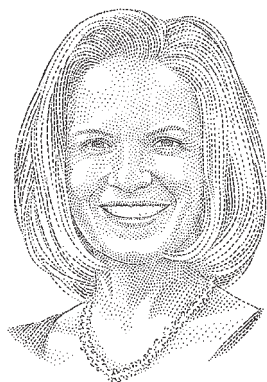
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Preface



Larry F. Chu, MD, MS



Andrea J. Fuller, MD

We designed *Point of Care Essentials* to be used by practicing anesthesiologists during perioperative procedures and treatments. **It is not a textbook of anesthesiology.** There are already many excellent texts that provide detailed explanations of the principles and practice of perioperative medicine. These cards are a companion to the *Manual of Clinical Anesthesiology* and are not intended to be used as a sole source of information about any topic, procedure, or process in anesthesiology.

These cards are a set of **cognitive aids** designed to guide the practitioner through a series of steps necessary to complete a process or procedure. We anticipate that it may be necessary for practitioners who are unfamiliar with certain procedures to reference other anesthesia texts, such as the *Manual of Clinical Anesthesiology*, for additional information.

We have designed these cards to appeal to today's highly visual learners by incorporating full-color graphics, illustrations, and photographs. We believe the spiral-bound and laminated format of *Point of Care Essentials* creates a highly portable reference that brings practical information where it is needed most: in the operating room, on the wards, and at the patient bedside.

Larry F. Chu and Andrea J. Fuller,
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Major portions of this text were developed by the Stanford Anesthesia Informatics and Media Lab, specifically the visual atlases and cognitive aids. We would like to recognize these important contributors to this book.

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1

Normal Values

Larry F. Chu, MD, MS • Nathaen Weitzel, MD

NORMAL

Aortic annulus size	1.8–2.3 cm
Mitral annulus size	3.0–3.5 cm
Aortic VTI	18–25 cm
Mitral VTI	10–13 cm

MITRAL VALVE

Normal area	4.0–6.0 cm ²
Mild stenosis	1.5–2.5 cm ²
Moderate stenosis	1.0–1.5 cm ²
Severe stenosis	<1.0 cm ²

MITRAL VALVE MEAN GRADIENT

Mild MS	<5 mm Hg
Moderate MS	5–10 mm Hg
Severe MS	>10 mm Hg

MITRAL REGURGITATION (MR)

	Mild	Moderate	Severe ^a
Vena contracta (cm)	<0.3	0.3–0.7	>0.7
Color Doppler jet area (cm ²)	<4.0	4–8	>8.0 ^b

^aERO ≥ 0.4 cm², radius ≥ 1.0 cm, color

Nyquist = 40 cm/s, MR peak velocity = 500 cm/s

^bor wall hugging jet.

AORTIC VALVE

Normal area	2.5–4.5 cm ²
Mild stenosis	>1.5 cm ²
Moderate stenosis	1.0–1.5 cm ²
Severe stenosis	<1.0 cm ²

AORTIC STENOSIS

	Mild	Moderate	Severe
Peak jet velocity (m/s)	<3.0	3–4	>4.0
Mean gradient (mm Hg)	<25	25–40	>40

AORTIC REGURGITATION

	Mild	Moderate	Severe
Vena contracta (cm)	<0.3	0.3–0.6	>0.6
PHT (ms)	>500	<500–200	<200
Decel rate (m/s ²)	<2.0	2.0–3.5	>3.5

CW Doppler evaluation: holosystolic flow reversal in descending aorta

Decel rate, deceleration rate; ERO, effective regurgitant orifice; PHT, pressure half time.

AR JET WIDTH AND LVOT RATIO

Mild AR	<25%
Moderate AR	25%–65%
Severe	>65%

AORTIC AND MITRAL REGURGITANT FRACTION

Mild	<30%
Moderate	30%–50%
Severe	>50%

PULMONARY HYPERTENSION

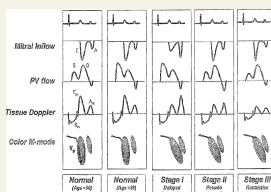
Mild	30–40 mm Hg
Moderate	40–70 mm Hg
Severe	>70 mm Hg
Severe mean PA pressure	>40 mm Hg
Normal dP/dt	>1,200 mm Hg/s (<27 ms)
Borderline	1,000–1,200 mm Hg/s (27–32 ms)
Abnormal	<1,000 mm Hg/s (>32 ms)

NORMAL LV SYSTOLIC FUNCTION PARAMETERS

Stroke volume	70–100 mL
Cardiac output	4–8 L/min
Fractional shortening	28%–44%
Fractional area change	40%–75%
Ejection fraction	55%–70%
Mild dysfunction	40%–55%
Moderate dysfunction	26%–39%
Severe dysfunction	<25%

LV HYPERTROPHY (TG SAX)

End-diastole	>1.2 cm
LV wall thickness	



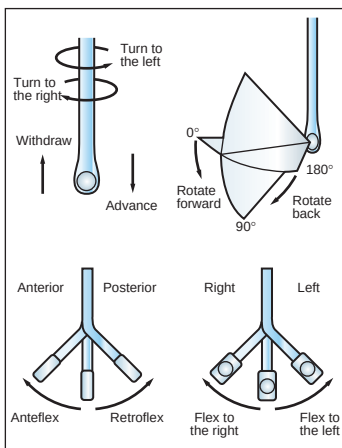
Patterns of diastolic dysfunction by TEE

2

Performing a TEE Examination

Once you have properly set up your TEE according to manufacturer's guidelines, taken care of the four A's (Antibiotics, ACT, ABG, Amicar) you may perform a TEE exam.

1. Place an OG tube and suction air out of the stomach.
2. Place approximately 10 cc of gel into the mouth.
3. Jaw lift and gently intubate the esophagus with the TEE probe, it should pass easily. **If you feel resistance, stop and reevaluate the positioning.** Occasionally direct laryngoscopy with a MAC 3 to visualize the esophagus assists in probe placement.
4. Start by advancing the probe to 35 cm at the incisors and then take a look for the 4 chamber view (0 degree) and evaluate LV/RV size and function. Evaluate the mitral (MV) and tricuspid valves. If desired, a 2 chamber (90 degrees) view can examine the LV apex for pathology.
5. Pull the probe out ever so slightly until the 5 chamber view is visualized (0 degree). Examine the MV and aortic valve (AV) at various angles and in color (see AV and MV pages).
6. Advance the probe to 40 to 45 cm and obtain the transgastric LV mid-papillary short axis view (0 degree) to assess LV filling and function and SWMA (segmental wall motion abnormalities). To obtain the transgastric view you will need to anteфлек the probe (push down on the wheel with your thumb so that turns clockwise).



7. The deep transgastric long axis view (see 20 views card) which is useful to assess the AV by Doppler (this view can be challenging to obtain).
8. Evaluate the aorta, beginning with the descending and moving up all the way to the arch. Note abnormalities such as dissection and plaques. The surgeon will occasionally ask you to look for their bypass cannulas in the aorta.

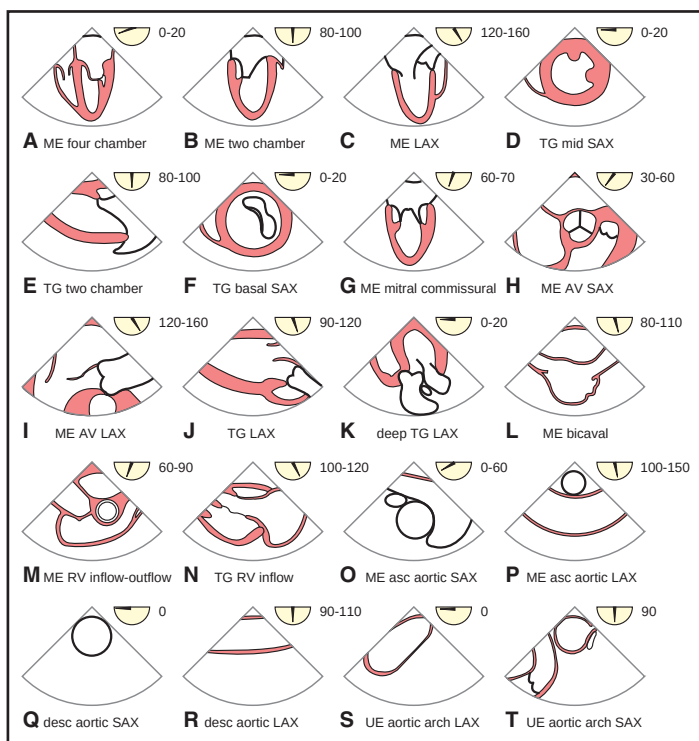
CAVEAT: This is an abbreviated exam. The ASE/SCA guidelines describe a comprehensive 20 view TEE examination. The key is to be systematic so important pathology and information is not missed during the ETT exam.

DID YOU KNOW? The contraindications for TEE include: UGI bleed, perforation, diverticulum, tumor, stricture, varices, and recent gastric or esophageal surgery.

3

ASE/SCA 20 View Exam Overview

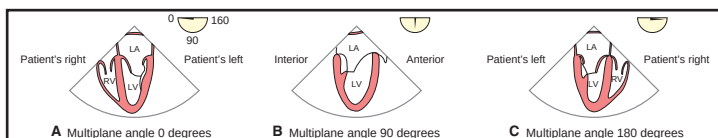
Shanthala Keshavacharya, MD



ASE/SCA 20 View Comprehensive TEE Examination

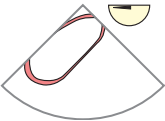
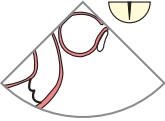
Journal of the American Society of Echocardiography, 12(10):887–900.

20 cross-sectional views composing the recommended comprehensive transesophageal echocardiographic examination. Approximate multiplane angle is indicated by the icon adjacent to each view. ME, mid esophageal (30 to 40 cm at incisors); LAX, long axis, TG, transgastric (40 to 45 cm at incisors); SAX, short axis; AV, aortic value; RV, right ventricle, asc, ascending; desc, descending; UE, upper esophageal (20 to 25 cm at incisors).



ASE/SCA 20 View Exam Card 1/4

Guided ASE/SCA 20 View Comprehensive TEE Examination (1/4)

20	A. Upper Esophageal (20–25 cm)	How to Obtain View	Comments
	1. Aortic arch LAX. 0 degree 	Obtained at the highest level. Can also be imaged by withdrawing probe after imaging the descending thoracic aorta evaluation.	Look for evidence of atherosclerosis, calcification, mobile plaques, and dissection flaps. PWD for flow reversal in AI.
	2. Aortic arch SAX. 90 degrees 	As above. Slightly retroflex the probe and move side to side to evaluate arch vessels.	As above. Examine PV, MPA. Spectral Doppler of PV, parallel intercept angle. Look for L brachiocephalic vein adjacent to L subclavian artery.
30	B. Mid esophageal (30–40 cm)	How to obtain view	Comments
	3. AV SAX. 30–50 degrees 	Advance the probe from the above view to obtain the classic “Mercedes-Benz” sign at 30–50 degrees.	Highest and most anterior valve. RCC is anterior, NCC is adjacent to IAS, the remainder is LCC. Look for R & L coronary arteries. CFD for AI, any calcification, vegetation, prolapse, restriction of leaflet motion or dissection.
	4. AV LAX. 120–150 degrees 	Move the probe slightly to open up the Ao and LVOT, with valve cusps opening parallel to Ao wall.	Look for valve thickening, opening motion, prolapse, vegetation, dissection. CFD for AI. Measure annulus, sinus, STJ and ascending Ao.
	5. RV inflow-outflow view. 60–80 degrees 	From the aortic valve view rotate forward to 60–80 degrees.	Evaluate TV, PV with and without CFD. Spectral (CW) Doppler of TR jet for RVSP. Look for PA catheter, pacing wires.
	6. 4 chamber view. 0–20 degrees 	Advance the probe slightly from the aortic image. Retroflex and angle 0–20 degrees to minimize LVOT and to open the LV apex to prevent foreshortening.	Evaluate all the chambers for size, wall motion, thrombi (in LAA and LV apex), and thickening. Evaluate TV, MV with and without CFD, mitral inflow spectral Doppler. Evaluate septal motion and thickening.

AI, aortic insufficiency; Ao, aorta; CFD, color flow Doppler; CW, color wave; IAS, interatrial septum; LAA, left atrial appendage; LCC, left coronary cusp; LVOT, left ventricular outflow tract; MPA, main pulmonary artery; NCC, noncoronary cusp; PA, pulmonary artery; PV, pulmonary vein; PWD, pulse wave Doppler; RCC, right coronary cusp; RVSP, right ventricular systolic pressure; STJ, sinotubular junction; TV, tricuspid valve.

ASE/SCA 20 VIEW EXAM CARD 2/4

Guided ASE/SCA 20 View Comprehensive TEE Examination (2/4)

30	B. Mid Esophageal (30–40 cm)	How to Obtain View	Comments
	7. Mitral commissural view. 60–80 degrees 	Rotate the angle forward to 60–80 degrees to get “trap door” view.	Measure the commissural distance for annular dilation. Look for restriction, calcification, redundancy of leaflet motion, CFD. See MV card.
	8. 2-chamber view. 80–100 degrees 	Increase the angle further to obtain the 2 chamber view.	Evaluate MV, CFD, look for regional wall motion, thickening in anterior and inferior wall, also examine the LAA for evidence of thrombus. PWD: A LAA velocity >0.5 m/s indicates good atrial contractility and less likelihood of thrombus or low flow state. PWD LUPV.
	9. LV long axis view. 120–160 degrees 	Increase the angle further from above image.	Examine the LV anteroapical, posterior wall thickening and wall motion. Look for SAM.
	10. Bicaval view. 80–110 degrees 	From 4-chamber view, rotate the probe to the right in order to center the RA. Increase the multiplane angle to 80–110 degrees.	Examine RA, RAA, IAS, SVC, IVC. CFD for ASD, PFO. Perform bubble study, look for lines, aid in femoral cannulation.
	11. ME Asc Ao SAX. 0–60 degrees 	From AV SAX pull the probe back to evaluate great vessels.	Can be used to image Asc Ao, MPA, RPA, LPA and SVC. Look for PAC, saddle embolus in MPA and bifurcation, Ao dissection, plaque.
	12. ME Asc Ao LAX. 100–150 degrees 	As above, increase the angle 100–150 degrees.	Can be used to view the asc Ao in long axis and can image RPA in SAX.

Ao, aorta; Asc, ascending; ASD, atrial septal defect; CFD, color flow Doppler; IAS, interatrial septum; IVC, inferior vena cava; LAA, left atrial appendage; LUPV, left upper pulmonary vein; MV, mitral valve; MPA, main pulmonary artery; PA, pulmonary artery; PAC, pulmonary artery catheter; PFO, patent foramen ovale; PV, pulmonary vein; PWD, pulse wave Doppler; RA, right atrium; RAA, right atrial appendage; RPA, right pulmonary artery; RVSP, right ventricular systolic pressure; SAM, systolic anterior motion; SAX, short axis; SVC, superior vena cava; TV, tricuspid valve.

ASE/SCA 20 View Exam Card 3/4

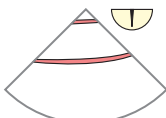
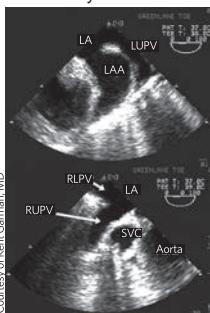
Guided ASE/SCA 20 View Comprehensive TEE Examination (3/4)

40	C. Trans Gastric Views (40–45 cm)	How to Obtain View	Comments
	13. Basal MV SAX. 0–20 degrees 	Advance the probe gently to the stomach and ante-flex the tip. Pull the probe back until the MV is seen.	Evaluate the MV, trace the MV area. CFD to localize the leaflet pathology.
	14. Mid papillary SAX. 0–20 degrees 	Advance the probe to image at the level of the papillary muscle.	Assess global ventricular function, regional WMA all RCA, LAD, LCX distributions. Evaluate preload. Obtain cine loop for comparison. M Mode for LV dimension.
	15. Trans gastric 2 chamber. 80–100 degrees 	Increase the angle to 90 degrees from the above image.	Evaluate the mitral apparatus i.e., papillary muscle, chordae, leaflet, anterior and inferior basal ventricular wall motion. Look for restriction or redundancy of chordae.
	16. LV long axis. 90–130 degrees 	Further advance the angle from the above image.	Provides reasonable image for spectral Doppler interrogation of AV and LVOT.
	17. RV inflow. 100–120 degrees 	Rotate the probe to right form mid papillary view to center the RV and increase the angle.	Examine right atrium, right ventricle, tricuspid valve and papillary muscle. Further rotation of the angle can sometimes reveal RVOT and PV.
	18. Deep trans gastric view. 0–20 degrees 	Advance the probe deep into stomach and maximally ante-flex and slowly withdraw the probe. This view is hard to obtain and probe needs manipulation in terms of advance, pull, rotate etc.	This view aligns the probe almost parallel to the heart to facilitate spectral Doppler interrogation of AV and LVOT.

AV, aortic valve; CFD, color flow Doppler; LCA, left coronary artery; LCx, left circumflex; LVOT, left ventricular outflow tract; MV, mitral valve; PV, pulmonary vein; RCA, right coronary artery; RV, right ventricle; RVOT, right ventricular outflow tract; WMA, wall motion abnormality.

ASE/SCA 20 View Exam Card 4/4

Guided ASE/SCA 20 View Comprehensive TEE Examination (4/4)

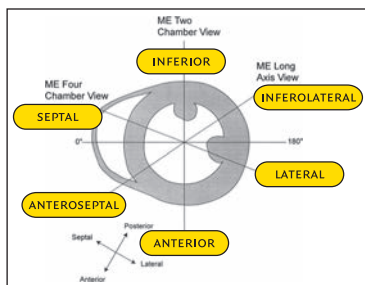
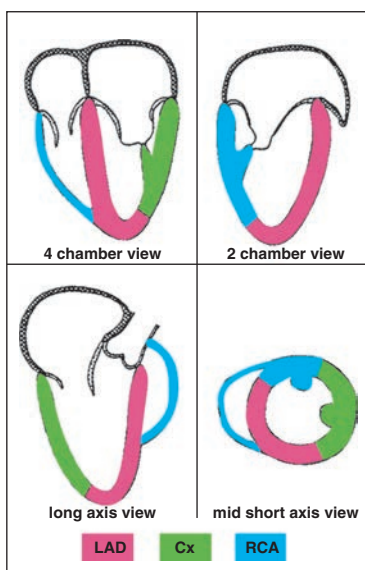
40	C. Trans Gastric Views (40–45 cm)	How to Obtain View	Comments
	19. Evaluation Of Desc Thoracic. 0 degree  A 90–130 degrees  B	For complete examination of the aorta, rotate the probe to the left until the descending thoracic aorta is visualized. Reduce the image depth and increase the transducer frequency. Withdraw the probe slowly to image the entire length up to the aortic arch. Rotate the probe as required to keep the image in the center.	Image in 0 and 90 degrees. Look for dissection, false and true lumen plaques, aneurysm or thrombus. PWD for flow reversal in AI.
	20. Pulmonary veins  Courtesy of Kent Garman MD	Begin with 4-chamber view. LUPV—Adj to LAA at 0 and 90 degrees. LLPV—turn probe further left and advance 1–2 cm. RUPV—turn probe to right from LAA at 90 degrees. RLPV—advance 1–2 cm from above.	Confirm the pulmonary vein with CFD. Do PWD to evaluate diastolic dysfunction and assess the severity of MR. Localize source air during de-airing maneuver.
	21. Coronary sinus 0–20 degrees 	Obtain 4-chamber view. Rotate the probe to center TV. Advance 1–2 cm and retroflex.	Assist with placement and confirmation of retrograde cardioplegia catheter. Can also be imaged in SAX 2-chamber view, transgastric basal view and in cross section in bicaval view.

Ao, aorta; AV, aortic valve; CFD, color flow Doppler; CWD, continuous wave Doppler; IAS, inter atrial septum; LAA, left atrial appendage; LAX, long axis view; LCC, left coronary cusp; LVOT, left ventricular outflow tract; NCC, noncoronary cusp; PV, pulmonary vein, right, left, upper, lower; PWD, pulse wave Doppler; RCC, right coronary cusp; RVOT, right ventricular outflow tract; SAX, short axis view; WMA, wall motion abnormality.

4

Evaluation of Myocardial Perfusion

Larry F. Chu, MD, MS • Nathaen Weitzel, MD



Once you have mastered obtaining the different TEE views, you can use your skills to assist the surgeon in identifying areas of myocardial ischemia.

This can be done by recording loops during the pre-bypass period and comparing contractility and wall motion abnormalities to the post-bypass heart.

By looking for segmental wall motion abnormalities, you can help localize areas of ischemia to specific vessels.

The mid short axis view (see “20 view overview, D”) may be best to visualize LV function. However, changes that occur in the apex will not be visualized.

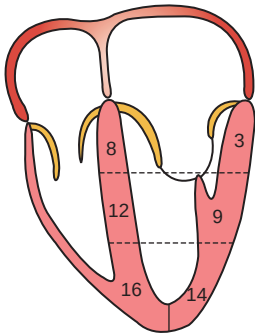
You should also familiarize yourself with the orientation of the heart in the mid short axis view (Fig. 4.2). The mnemonic “**SALI**” describes the main four segments—septal, anterior, lateral, and inferior. The remaining two segments are “sandwiched in between”—anteroseptal and inferolateral.” You should know what these are and how to identify them on your TEE examination.

Qualitative grading of wall motion is:

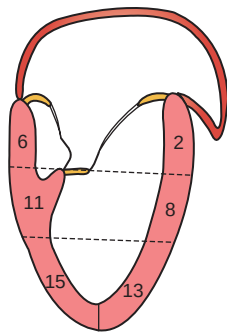
- 1 = Normal (>30% thickening)
- 2 = Mildly hypokinetic (10% to 30%)
- 3 = Severely hypokinetic (<10%)
- 4 = Akinetic (does not thicken)
- 5 = Dyskinetic (paradoxical movement)

DID YOU KNOW? TEE experts divide the left ventricle into 16 segments by examining 5 cross-sectional views (see “Left Ventricle 16 Segment Model”).

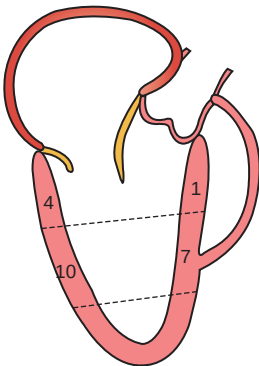
Left Ventricle 16 Segment Model



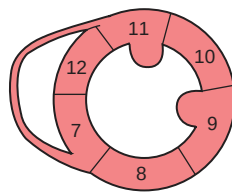
A 4 Chamber view



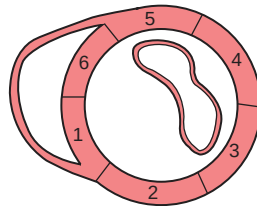
B 2 Chamber view



C Long axis view



D Mid short axis view



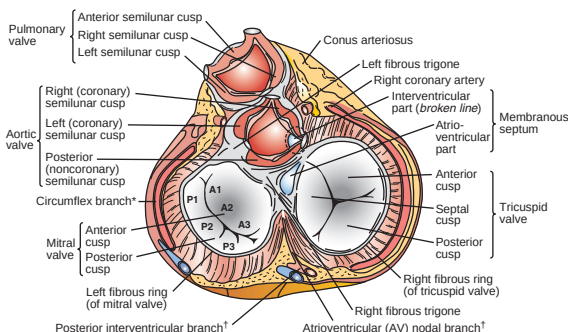
E Basal short axis view

Basal Segments	Mid Segments	Apical Segments
1 = Basal anteroseptal	7 = Mid anteroseptal	13 = Apical anterior
2 = Basal anterior	8 = Mid anterior	14 = Apical lateral
3 = Basal lateral	9 = Mid lateral	15 = Apical inferior
4 = Basal posterior	10 = Mid posterior	16 = Apical septal
5 = Basal inferior	11 = Mid inferior	
6 = Basal septal	12 = Mid septal	

5

Evaluation of the Mitral Valve

Larry F. Chu, MD, MS • Nathaen Weitzel, MD



The anatomy displayed above, and on following page will help to orient you to the valve structures seen in each 2-D TEE view. Begin by inserting the probe to 30 to 35 cm for the ME 4-chamber view and identify the anterior and posterior mitral leaflets. The anterior leaflet will be on the left and the posterior leaflet on the right. Move through the 5 ME views to fully evaluate leaflet anatomy and function. As the multiplane angle is increased beyond 90 degrees, note that the posterior leaflet will be to the left of your screen, and the anterior to the right. The ME LAX view (120 degrees) is a key view looking at the coaptation of A2/P2 for most patients.

Once oriented, assess the overall structure and function of the valve. This includes looking for and describing prolapsing or flail segments, stenotic or restricted leaflet motion (CW Doppler through the valve), and degree of annular dilation (try to describe lesion by location—i.e., prolapse at A1). Color Doppler is paramount in evaluation of MR and aids in locating the site of the lesions. Surgeons want to know the degree of MR, whether it is central or eccentric, which segment is affected (i.e., P2 flail), mitral valve dimensions (commissural view, ME LAX view), and degree of annular calcification.

Echocardiographic Methods to Evaluate Mitral Regurgitation

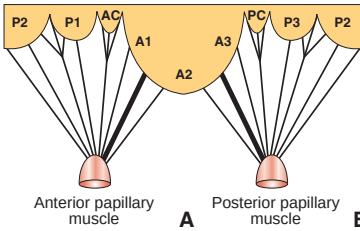
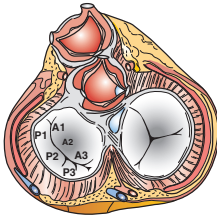
Method	Mild	Moderate	Severe
Vena contracta (cm)	<0.3	0.3–0.7	>0.7
Spatial area mapping of the color Doppler regurgitant jet	1.5–4.0 cm ²	4.0–8.0 cm ²	>8.0 cm ²
Pulmonary vein flow characteristics	S wave > D wave		Systolic flow reversal
Estimation of the mitral regurgitant fraction	20%–30%	30%–50%	>50%
Estimation mitral effective regurgitant orifice by the PISA method	<20 mm ²	20–39 mm ²	>40 mm ²
Secondary 2-D changes: left atrial enlargement	Mild	Moderate	Severe
Peak E-wave velocity			>1.2 m/s

Assessment of mitral stenosis severity

	Normal Values	Mild	Moderate	Severe
Valve area (cm ²)	4–6	1.5–2.0	1.0–1.5	<1.0
Mean gradient (mm Hg)	0–4	5	5–10	>10
Pressure half-time (ms)	70–100	100–150	150–220	>220

Calculation of mitral valve area

$\text{MVA (cm}^2\text{)} = \frac{220}{\text{Pressure half-time}} = \frac{760}{\text{Deceleration time}}$	
$\text{LVOT (area)} \times \text{LVOT (TVI)} = \text{MV (area)} \times \text{MV (TVI)} \text{ \{continuity equation\}}$	
$\text{PISA (area)} \times \text{PISA (velocity)} = \text{MV (area)} \times \text{MV (velocity)} \text{ \{PISA method\}}$	



Mitral Valve ASE/SCA Terminology (per Carpentier)

Chordal relationships:
Anterior leaflet divided
into A1, A2, A3.

Posterior leaflet divided
into P1 (anterolateral
scallop), P2 (middle scal-
lop), P3 (posteromedial
scallop).

Commissural clefts
not named anterior or
posterior.

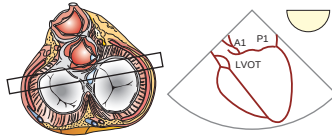
Chordae arising from the
anterior papillary muscle
attach to A1, AC, P1, and
lateral half of P2, A2.

Chordae arising from the
posterior papillary muscle
attach to A3, PC, P3, and
medial half of P2, A2.

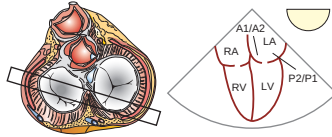
Carpentier Terminology

Column A illustrates
the cross section the
midesophageal views
make through the mitral
valve leaflets. Anatomical
diagram is drawn viewing
mitral and tricuspid
leaflets from their atrial
side. Column B shows
schematic of TEE view
seen. Section transversed
by TEE plane may vary
from patient to patient,
however general relation-
ship remains.

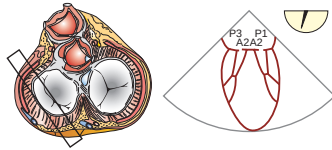
Midesophageal
3 chamber
view



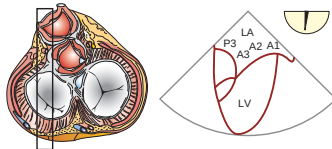
Midesophageal
4 chamber
view



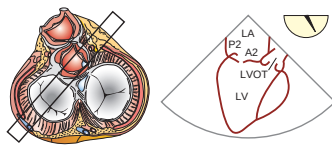
Midesophageal
commissural
view



Midesophageal
2 chamber
view



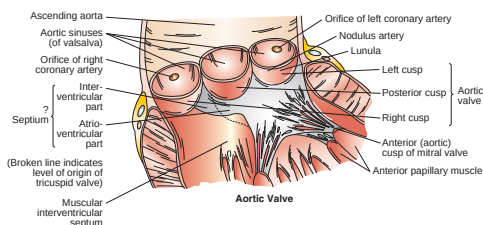
Midesophageal
long axis view
(longitudinal)



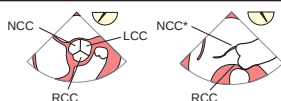
6

Evaluation of the Aortic Valve

Larry F. Chu, MD, MS • Nathaen Weitzel, MD



Echocardiographic Views of the Aortic Valve



Left: Mid-esophageal short axis view of Aortic valve leaflets. **Right:** Mid-esophageal long axis view of the aortic valve leaflets. NCC, noncoronary cusp; LCC, left coronary cusp; RCC, right coronary cusp.

* Can be either NCC or LCC

Echocardiographic Methods to Evaluate Aortic Valve

Method	Mild	Moderate	Severe
QUALITATIVE METHODS TO ASSESS AORTIC REGURGITATION			
Angiographic data	1+	2+	3-4+
Color Doppler jet width	Central jet width <25% LVOT	Greater than mild no signs severe AR	Central jet width >65% LVOT
Doppler vena contracta width (cm)	<0.3	0.3-0.6	>0.6
QUANTITATIVE METHOD (CATH OR ECHO) TO ASSESS AORTIC REGURGITATION			
Regurgitant volume (mL/beat)	<30	30-59	≥60
Regurgitant fraction (%)	<30	30-49	≥50
Regurgitant orifice area (cm ²)	<0.1	0.1-0.29	≥0.3
Pressure half-time (ms)	>500	200-500	<200
ADDITIONAL CRITERIA TO ASSESS AORTIC REGURGITATION			
Left ventricular Size			Increased
Aortic diastolic flow reversal			Holodiastolic Flow Reversal
Assessment of aortic stenosis			
Peak jet velocity (m/s)	<3.0	3.0-4.0	>4.0
Mean gradient (mm Hg)	<25	25-40	>40
Valve area (cm ²)	>1.5	1.0-1.5	<1.0
Valve area index (cm ² /m ²)			<0.6

The AV lends itself to high quality TEE imaging due to its anatomic location. The valve is oriented such that slight anterior flexion of the probe is typically required to obtain ideal imaging. Evaluation should be carried out utilizing the ME AV SAX and LAX views, and the deep transgastric LAX or transgastric LAX view. Look for the degree of calcification along with any flail/prolapsing segments of the leaflets. Additionally, look for possibility of congenital lesions such as a bicuspid valve. Color Doppler, along with CW Doppler evaluation are key in evaluation of regurgitant flow along with elements of stenosis. Heavy calcification should be reported to the surgeons, along with degree of mitral annular calcification as this can make an AVR more difficult.

Assessment of the AV annular size, along with dimensions of the aortic root are helpful in aortic valve surgery. Degree of atherosclerotic disease in the ascending aorta should be assessed as well. Finally, look for evidence of dissection in all cases, and if found assess the proximity to the coronary arteries and aortic valve leaflets.

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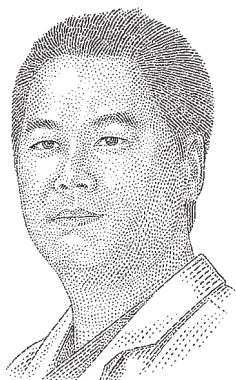
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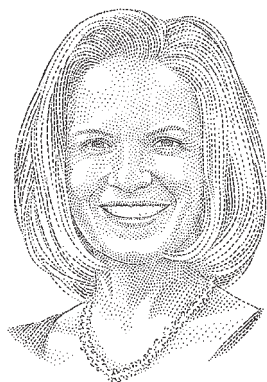
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Preface



Larry F. Chu, MD, MS



Andrea J. Fuller, MD

We designed *Point of Care Essentials* to be used by practicing anesthesiologists during perioperative procedures and treatments. **It is not a textbook of anesthesiology.** There are already many excellent texts that provide detailed explanations of the principles and practice of perioperative medicine. These cards are a companion to the *Manual of Clinical Anesthesiology* and are not intended to be used as a sole source of information about any topic, procedure, or process in anesthesiology.

These cards are a set of **cognitive aids** designed to guide the practitioner through a series of steps necessary to complete a process or procedure. We anticipate that it may be necessary for practitioners who are unfamiliar with certain procedures to reference other anesthesia texts, such as the *Manual of Clinical Anesthesiology*, for additional information.

We have designed these cards to appeal to today's highly visual learners by incorporating full-color graphics, illustrations, and photographs. We believe the spiral-bound and laminated format of *Point of Care Essentials* creates a highly portable reference that brings practical information where it is needed most: in the operating room, on the wards, and at the patient bedside.

Larry F. Chu and Andrea J. Fuller,
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Major portions of this text were developed by the Stanford Anesthesia Informatics and Media Lab, specifically the visual atlases and cognitive aids. We would like to recognize these important contributors to this book.

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1

Regional Anesthesia in the Anticoagulated Patient

Larry F. Chu, MD, MS • Bassam Kadry, MD

WARNING

The following cognitive aid was created using the 2010 Practice Advisory from the American Society of Regional Anesthesia for patients receiving regional anesthesia and antithrombotic therapy and Fleischmann KH, et al. "Practice guidelines often fail to keep pace with the rapid evolution of medicine: a call for clinicians to remain vigilant and revisit their own practice patterns." *Reg Anesth Pain Med* 2010; 35(1):4–7. As noted in their guidelines, "An understanding of the complexity of this issue is essential to patient management; a 'cookbook' approach is not appropriate. Rather, the decision to perform spinal or epidural anesthesia/analgesia and the timing of catheter removal in a patient receiving antithrombotic therapy should be made on an individual basis, weighing the small, although definite risk of spinal hematoma with the benefits of regional anesthesia for a specific patient." Deriving time intervals to minimize risk of hematoma depends on the amount of time it takes the drug to undergo three elimination half-lives. Periodic neurological assessments should be conducted for minimum of 24 hours post intervention if clinical situation is unclear.

Guidelines for Regional Anesthesia in the Anticoagulated Patient (Chu and Kadry)

Anticoagulant	Time Interval for Placement or Removal of Catheter After Last Dose	Time Interval to Restart Anticoagulation After Catheter Removal
Abciximab	48 h	12 h
Argatroban	6 h; check ACT or PTT	2 h
Cilostazol (alone)	None	None
Cilostazol + Aspirin	48 h	1 h
Clopidogrel	7 d	24 h
Dalteparin ^{a,b} 120 U/kg q 12h	24 h	Indwelling catheters should be removed prior to starting LMWH thromboprophylaxis. After removal: minimum of 2 h. If catheter not removed, wait 24 h.
Dalteparin ^{a,b} 200 U/kg qd	24 h	Not explicitly specified
Enoxaprin (low dose) ^{a,b} (0.5 mg/kg/qd)	10–12 h	2 h
Enoxaprin (high dose) ^{a,b} (1 mg/kg q 12h)	24 h	Indwelling catheters should be removed prior to starting LMWH thromboprophylaxis. After removal: minimum of 2 h. If catheter not removed, wait 24 h.

The recommendations in the following tables were adapted from the 2010 Consensus Conference of the American Society of Regional Anesthesia and Pain Medicine, “Regional Anesthesia in the Patient Receiving Antithrombotic or Thrombolytic Therapy (Third Edition).” *Reg Anesth Pain Med* 2010; 35(1):64–101 and Fleischmann KH, et al. Practice guidelines often fail to keep pace with the rapid evolution of medicine: a call for clinicians to remain vigilant and revisit their own practice patterns. *Reg Anesth Pain Med* 2010; 35(1):4–7. Variances from the recommendations may be acceptable based on the judgment of the responsible anesthesiologist. The recommendations are designed to encourage quality patient care and safety but cannot guarantee a specific outcome. They are subject to revision at any time and updates can be found at <http://www.asra.com>

^a Monitoring of anti-Xa level is not predictive of the risk of bleeding and is therefore NOT recommended.

^b The presence of blood during needle and catheter placement does not necessitate postponing surgery, however LMWH therapy in this setting should be delayed for 24 h.

Guidelines for Regional Anesthesia in the Anticoagulated Patient (Chu and Kady)

Anticoagulant	Time Interval for Placement or Removal of Catheter After Last Dose	Time Interval to Restart Anticoagulation After Catheter Removal
Enoxaprin (high dose) (1.5 mg/kg qd)	24 h	Indwelling catheters should be removed prior to starting LMWH thromboprophylaxis. After removal: minimum of 2 h. If catheter not removed, wait 24 h.
Eptifibatide Tirofiban	8 h	4 h
Fondaparinux	2.5 mg: 4 d 5 mg: 7 d	Suggest 12 h Suggest 24 h
Heparin IV ^c	2–4 h, PTT < 35	1 h
Heparin SC 5000 U BID	None	None
NSAIDS Cox2 Inhibitors Herbal	None	None
Ticlopidine	14 d	Not explicitly specified

^c Because heparin-induced thrombocytopenia (HIT) may occur during heparin administration, patients receiving heparin > 4d should have a platelet count prior to neuraxial block.

“An understanding of the complexity of this issue is essential to patient management; a “cookbook” approach is not appropriate. Rather, the decision to perform spinal or epidural anesthesia/analgesia and the timing of catheter removal in a patient receiving antithrombotic therapy should be made on an individual basis, weighing the small, although definite risk of spinal hematoma with the benefits of regional anesthesia for a specific patient.”

Guidelines for Regional Anesthesia in the Anticoagulated Patient (Chu and Keady)

Anticoagulant	Time Interval for Placement or Removal of Catheter After Last Dose	Time Interval to Restart Anticoagulation After Catheter Removal
Tinzaparin ^{a,b} 175 U/kg qd	24 h	Not explicitly specified
Tirofiban	8 h	4 h
Warfarin ^{d,e,f} 5 mg/PO (low dose)	Patient on chronic warfarin therapy must stop for 4–5 d. Patients receiving an initial dose 24 h prior to surgery or who have already received a second dose should have PT/INR checked prior to block placement (Goal: INR < 1.5)	An INR > 3 should prompt the physician to withhold or reduce the warfarin dose in patients with indwelling catheters. Neuraxial catheters should be removed when the INR is < 1.5. A neurological assessment is recommended for at least 24 h after catheter removal if in doubt.

^aEarly after discontinuation of warfarin, PT/INR reflect predominately factor VII levels. In spite of acceptable factor VII levels, factors II and X levels may not be adequate for normal hemostasis. Thus, caution should be used when placing blocks in patients recently disconnected from chronic warfarin therapy.

^ePT/INR should be monitored daily and checked prior to catheter removal if the initial dose was given more than 36 h preoperatively.

^fNeurologic testing of sensory and motor function should be performed routinely, and continued at least 24 h after catheter removal (and longer if INR was > 1.5).

2

US-Guided Interscalene Block

By Edward R. Mariano, MD, MAS • Larry F. Chu, MD, MS •
Vanessa J. Loland, MD

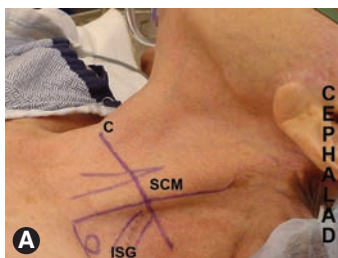
Patient Position: Position the patient supine with the back slightly elevated. A small shoulder roll may be placed for slight neck extension. With the head turned away from the side to be blocked, the patient should lift the head to aid in the identification of the sternocleidomastoid (SCM) muscle.

Needle Size: 22 to 17-gauge, 50 to 100-mm block needle

Volume: 20 to 40-mL local anesthetic

Anatomic Landmarks

A A line should be drawn along the posterior border of the SCM. The cricoid cartilage should be identified and a line drawn along a skin crease at this level to approximate C6 level. Standing next to the head of the bed, palpate the quadrant closest to the clavicle posterior to the SCM while the patient takes a forceful inspiration through the nose. This should delineate the interscalene groove and allow marking of the anterior and middle scalene muscles.



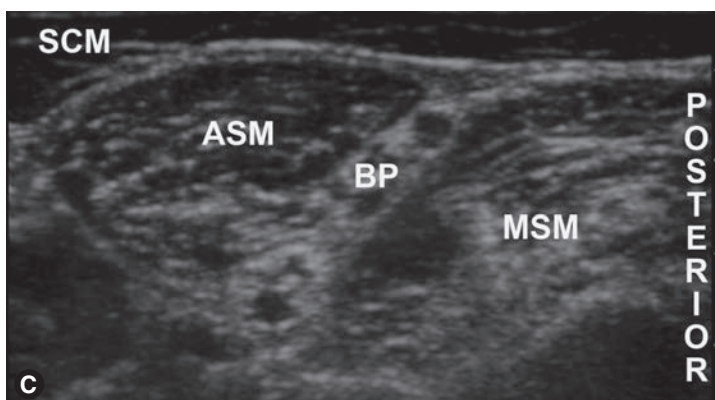
A. Surface anatomy relevant to the interscalene block. SCM, sternocleidomastoid muscle; C, cricoid cartilage; ISG, interscalene groove. **B.** A HF linear transducer is placed perpendicular to skin posterior to the sternocleidomastoid muscle. The block needle is inserted posterior to the transducer and directed anteromedially for in-plane needle guidance.

Approach and Technique

B With a high-frequency (HF) linear transducer positioned perpendicular to skin over the posterior border of the SCM, **C** the brachial plexus is visualized in short-axis between the anterior and middle scalene.

After sterile skin preparation, a local anesthetic skin wheal is raised posterior to the edge of the ultrasound transducer.

US-GUIDED INTERSCALENE BLOCK



C. Short-axis image of the brachial plexus in the interscalene groove. SCM, sternocleidomastoid muscle; ASM, anterior scalene muscle; MSM, middle scalene muscle; BP, brachial plexus.

The block needle is inserted through the skin wheal and directed anteriorly using in-plane guidance toward the target nerve bundle.

Once the needle tip passes through the middle scalene muscle into the interscalene groove, local anesthetic is injected incrementally after a negative aspiration test for blood until the circumferential injectate spread is visually confirmed.

Evaluation of Block

Motor testing

Strength of elbow flexion against resistance tests the biceps muscle innervated by the musculocutaneous nerve. Strength of elbow extension tests the triceps muscle innervated by the radial nerve. Strength of shoulder abduction tests the deltoid muscle innervated by the axillary nerve.

Sensory testing

Pinching the base of the index finger, small finger, and medial aspect of the forearm assesses anesthesia in the distribution of the median, ulnar, and medial antebrachial cutaneous nerves, respectively. Pinching over the posterior aspect of the shoulder over the scapula evaluates the block of the suprascapular nerve.

3

US-Guided Supraclavicular Block

By Vanessa J. Loland, MD • Larry F. Chu, MD, MS •
Edward R. Mariano, MD, MAS

Patient Position: Position the patient supine with back slightly elevated. The head should be turned away from the side to be blocked and the arm placed at the side.

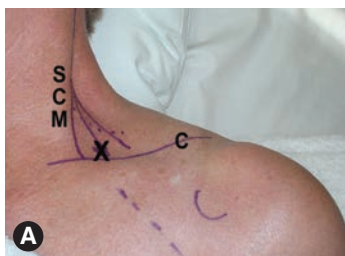
Needle Size: 22 to 17-gauge, 70 to 100-mm block needle

Volume: 20 to 40-mL local anesthetic

Anatomic Landmarks

A Important surface landmarks include the sternocleidomastoid (SCM) and clavicle.

The SCM may be identified by asking the patient to turn the head away from the affected side and flex the neck. Palpating the interscalene groove and subclavian artery pulsation posterior to the SCM is also helpful.



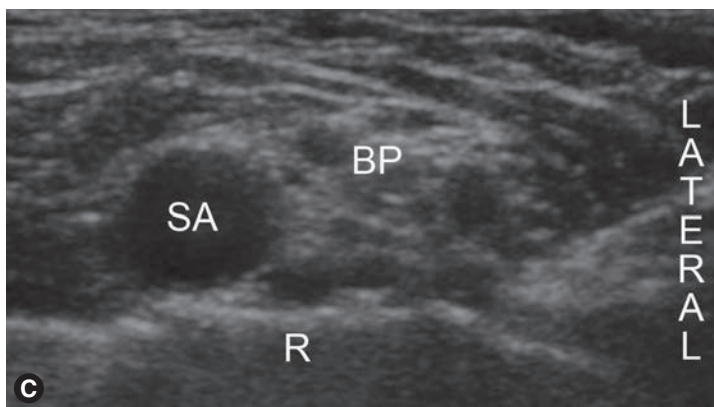
A. Surface anatomy relevant to the supraclavicular block. The “X” marks the suggested site for needle insertion when performing the plumb-bob technique with nerve stimulation. SCM, sternocleidomastoid muscle; C, clavicle. **B.** A high-frequency linear transducer is placed perpendicular to skin medial to the clavicle. The block needle is inserted lateral to the transducer and directed antero-medially for in-plane needle guidance.

Approach and Technique

B With a HF linear ultrasound transducer positioned cephalad and medial to the midpoint of the clavicle and oriented vertically, **C** the brachial plexus is visualized in short-axis posterolateral to the subclavian artery.

After sterile skin preparation, a local anesthetic skin wheal is raised lateral to the ultrasound transducer. The block needle is inserted through the skin wheal and directed antero-medially toward the subclavian artery.

US-GUIDED SUPRACLAVICULAR BLOCK



C. Short-axis image of the brachial plexus during supraclavicular block performance. SA, subclavian artery; R, first rib periosteum; BP, brachial plexus.

To ensure blockade of the C8 and T1 divisions for complete upper extremity anesthesia, the needle tip should be directed into the “corner pocket” between the posterolateral portion of the subclavian artery and first rib.

The total volume of local anesthetic can be injected incrementally after negative aspiration for blood until the injectate is visualized surrounding the entire plexus.

Evaluation of Block

Motor testing

Strength of elbow flexion against resistance tests the biceps muscle innervated by the musculocutaneous nerve. Similarly, strength of elbow extension tests the triceps muscle innervated by the radial nerve. Strength of shoulder abduction tests the deltoid muscle innervated by the axillary nerve.

Sensory testing

Pinching the base of the index finger, small finger, and medial aspect of the forearm assesses anesthesia in the distribution of the median, ulnar, and medial antebrachial cutaneous nerves, respectively. Pinching over the medial upper arm and elbow evaluates the block of the medial brachial cutaneous nerve.

4

US-Guided Infraclavicular Block

By Vanessa J. Loland, MD • Larry F. Chu, MD, MS •
Edward R. Mariano, MD, MAS

Patient Position: Position the patient supine with the head turned away from the side to be blocked and the arm abducted at 90 degrees (preferred) or at the patient's side.

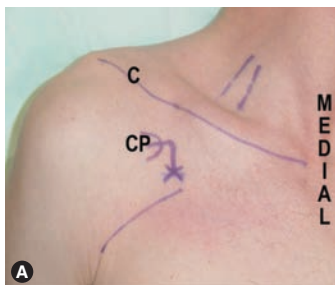
Needle Size: 22 to 17-gauge, 70 to 100-mm block needle

Volume: 20 to 40-mL local anesthetic

Anatomic Landmarks

The coracoid process is the most anterior portion of the scapula and can be palpated at the shoulder between the acromioclavicular joint and the deltopectoral groove. If the coracoid process has been correctly identified, forward elevation of the arm should rotate the scapula and displace the coracoid process superiorly and therefore not palpable.

- A** After identification of this landmark, a point is marked 2 cm medial and 2 cm caudad to the most anterior tip of the coracoid process.

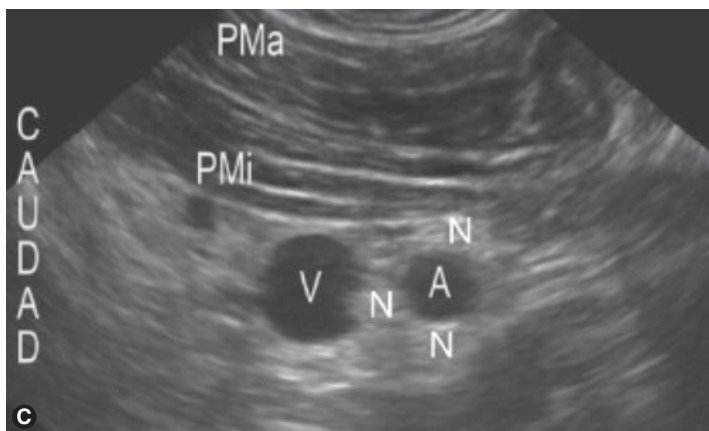


A. View of right shoulder demonstrating surface anatomy relevant to the infraclavicular block. CP, coracoid process of the scapula; C, clavicle. **B.** A small curvilinear transducer is placed medial and caudad to the coracoid process with the arm abducted 90 degrees to optimize the cross-sectional imaging of the neurovascular bundle. The block needle is inserted cephalad to the transducer and directed caudad for in-plane needle guidance.

Approach and Technique

- B** With a small curvilinear (preferred) or linear transducer positioned medial and caudad to the coracoid process and oriented vertically, **C** the brachial plexus cords are visualized in short-axis surrounding the axillary artery.

US-GUIDED INFRACLAVICULAR BLOCK



C. Short-axis image of the brachial plexus below the clavicle. PMa, pectoralis major muscle; PMi, pectoralis minor muscle; V, axillary vein; A, axillary artery; N, nerve (cord of the brachial plexus).

After sterile skin preparation, a local anesthetic skin wheal is raised cephalad to the ultrasound transducer. The block needle is inserted through the skin wheal and directed caudad toward the axillary artery. Local anesthetic can be injected around each individual cord or incrementally as a single injection posterior to the axillary artery after a negative aspiration for blood until the injectate spread surrounding all three cords is visually confirmed.

Evaluation of Block

Motor testing

Strength of elbow flexion against resistance tests the biceps muscle innervated by the musculocutaneous nerve. Strength of elbow extension tests the triceps muscle innervated by the radial nerve. Strength of shoulder abduction tests the deltoid muscle innervated by the axillary nerve.

Sensory testing

Pinching the base of the index finger, small finger, and medial aspect of the forearm assesses anesthesia in the distribution of the median, ulnar, and medial antebrachial cutaneous nerves, respectively. Pinching over the medial upper arm and elbow evaluates the block of the medial brachial cutaneous nerve.

5

US-Guided Axillary Block

Edward R. Mariano, MD, MAS • Larry F. Chu, MD, MS •
Vanessa J. Loland, MD

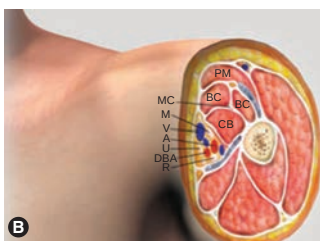
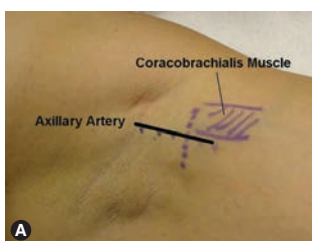
Patient Position: Position the patient supine with the head turned away from the side to be blocked and the affected arm abducted 90 degrees at the shoulder and flexed 90 degrees at the elbow.

Needle Size: 22 to 17-gauge, 50 to 100-mm block needle

Volume: 20 to 40-mL local anesthetic

Anatomic Landmarks

- A** The course of the axillary artery is palpated and marked in the proximal axilla.
- B** The expected location of the median nerve is superficial and lateral to the artery with the radial nerve posterior to the artery and the ulnar nerve medial to the artery.



A. Image of the left axilla demonstrating surface anatomy relevant to the axillary block: axillary artery and coracobrachialis muscle. **B.** Illustration of the cross-sectional anatomy through the axillary artery in the proximal axilla demonstrating the expected distribution of the terminal branch nerves in this location. PM, pectoralis major; MC, musculocutaneous; BC, biceps; CB, coracobrachialis; M, median; V, axillary vein; A, axillary vein; U, ulnar; DBA, deep brachial artery; R, radial; H, humerus. Reproduced from Bigeleisen P, Orebaugh S. Ultrasound guided axillary block. In: Chelly JE. Peripheral nerve blocks: a color atlas. 3rd Edition. Philadelphia: Lippincott Williams & Wilkins, 2009; 286, with permission.

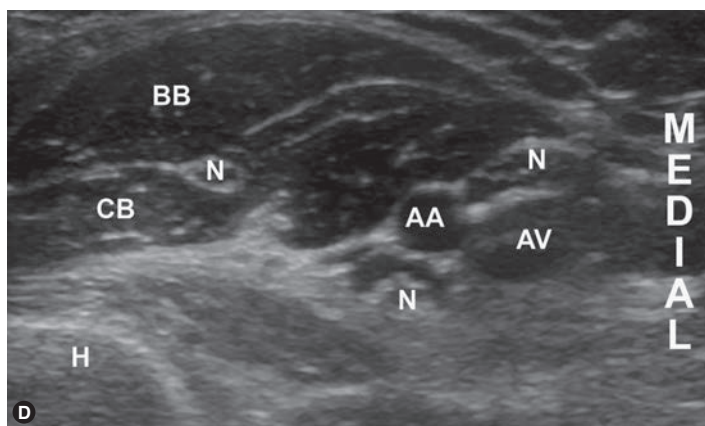


C. A linear ultrasound transducer is placed perpendicular to skin in the proximal axilla to visualize the axillary vessels and terminal branch nerves in cross section.

Approach and Technique

- C** With a HF linear transducer positioned perpendicular to skin over the axillary artery, **D** the terminal nerves can be visualized at various locations around the axillary artery.

US-GUIDED AXILLARY BLOCK



D. Short-axis image of the axillary vessels and terminal branch nerves in the proximal axilla. BB, biceps brachii muscle; CB, coracobrachialis muscle; H, humerus; AA, axillary artery; AV, axillary vein; N, nerve.

After sterile skin preparation, a local anesthetic skin wheal is raised lateral to the ultrasound transducer. The block needle is inserted through the skin wheal and medially directed toward the axillary artery. 5 to 10 mL of local anesthetic solution should be injected around each individual nerve to ensure a successful block.

Evaluation of Block

Motor testing

Strength of elbow flexion against resistance tests the biceps muscle innervated by the musculocutaneous nerve. Similarly, strength of elbow extension tests the triceps muscle innervated by the radial nerve.

Sensory testing

Pinching the base of the index finger, small finger, and medial aspect of the forearm assesses anesthesia in the distribution of the median, ulnar, and medial antebrachial cutaneous nerves, respectively. Pinching over the medial upper arm and elbow evaluates the block of the medial brachial cutaneous nerve.

6

US-Guided Distal Upper Extremity

Median, Radial and Ulnar Nerve Blocks

Amanda L. Peterson, MD • Larry F. Chu, MD, MS •
Edward R. Mariano, MD, MAS

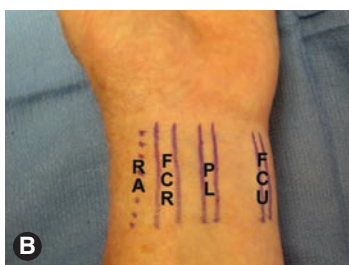
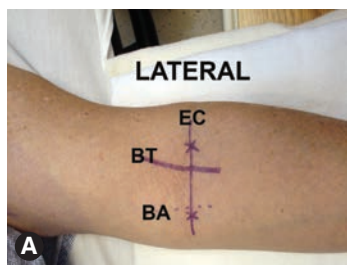
Patient Position: For elbow blocks, abduct the arm at the shoulder 90 degrees with the elbow in extension on a flat surface; in the ulnar nerve block, flex the elbow 90 degrees over patient's chest. For wrist blocks, abduct the arm at 90 degrees and position on flat surface with the wrist supinated.

Needle Size: 22-gauge, Tuohy-tip or B bevel block needle

Volume: 5 to 10-mL local anesthetic per individual nerve

Anatomic Landmarks

- A** Elbow: Extend the elbow and identify the intercondylar line. Palpate the brachial artery pulse medially and the tendon of the biceps brachii muscle laterally. Elevate the shoulder 90 degrees and flex the elbow 90 degrees across patient's chest to palpate the ulnar groove between the olecranon and the medial epicondyle of humerus where the ulnar nerve is located.
- B** Wrist: Supinate the forearm and identify the flexor carpi radialis, palmaris longus, and flexor carpi ulnaris. The radial artery runs medial to the radial nerve.



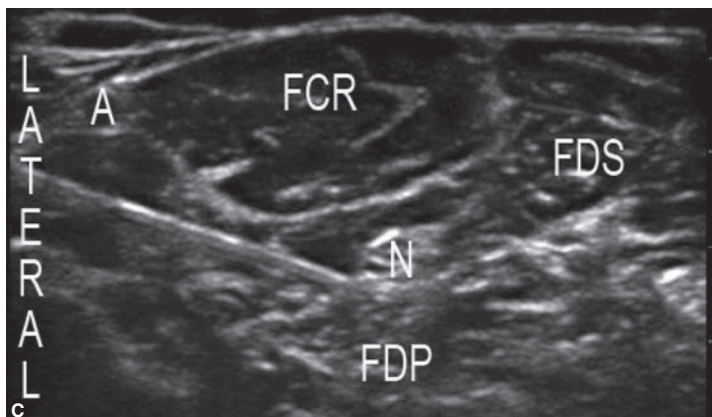
- A.** Surface anatomy relevant to nerve blocks at the elbow (left arm shown abducted 90 degrees at the shoulder). EC, elbow crease; BT, biceps tendon; BA, brachial artery.
- B.** Surface anatomy relevant to nerve blocks at the wrist (left hand and wrist shown). RA, radial artery; FCR, flexor carpi radialis tendon; PL, palmaris longus tendon; FCU, flexor carpi ulnaris tendon.

Median Nerve Block

Approach and Technique

Supinate the arm and place the ultrasound transducer perpendicular to skin.

- C** Visualize the median nerve in the mid-forearm medial to the radial artery and between flexor digitorum superficialis and flexor digitorum profundus muscles.



C. Short-axis ultrasound image of the mid-forearm demonstrating sonoanatomy relevant to the median nerve block. A, radial artery; FCR, flexor carpi radialis muscle; FDS, flexor digitorum superficialis muscle; FDP, flexor digitorum profundus muscle; N, median nerve.



- D** After sterile skin preparation and local anesthetic skin infiltration, insert the block needle lateral to the transducer and direct it medially toward the median nerve.

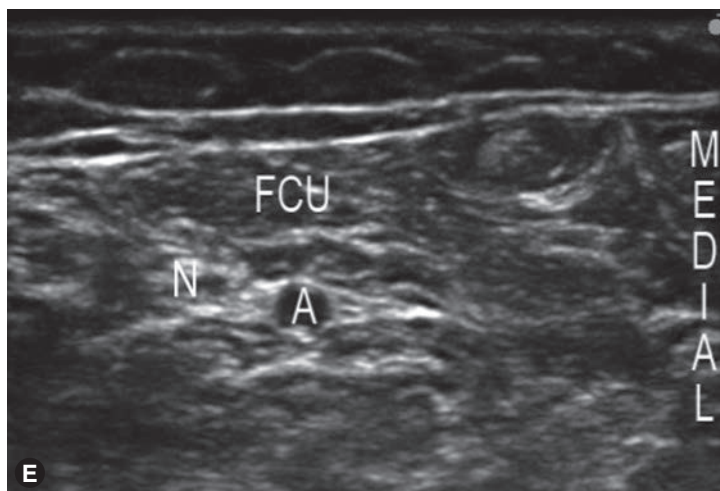
D. Ultrasound-guided median nerve block technique employing a high-frequency linear transducer and in-plane needle guidance.

Ulnar Nerve Block

Approach and Technique

Supinate the arm and place the ultrasound transducer perpendicular to skin.

- E** Identify the ulnar nerve in the mid-forearm deep to the flexor carpi ulnaris muscle and next to the ulnar artery.



E. Short-axis ultrasound image of the mid-forearm demonstrating sonoanatomy relevant to the ulnar nerve block. A, ulnar artery; FCU, flexor carpi ulnaris muscle; N, ulnar nerve.

- F** After sterile skin preparation and local anesthetic skin infiltration, insert the block needle lateral to the transducer and direct it medially toward the ulnar nerve.



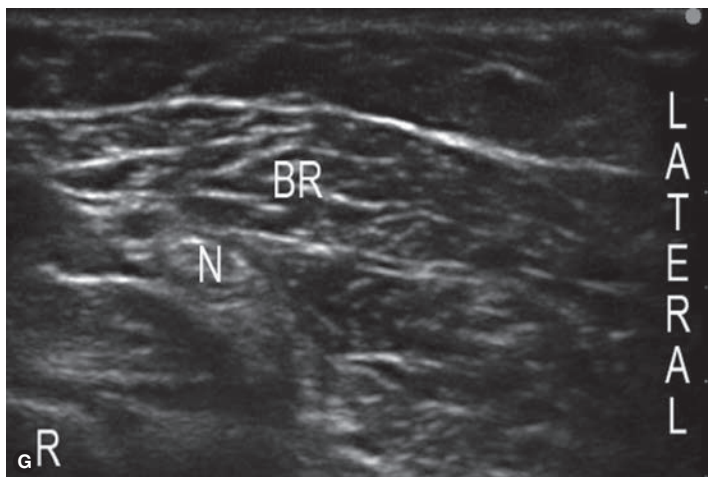
F. Ultrasound-guided ulnar nerve block technique employing a high-frequency linear transducer and in-plane needle guidance.

Radial Nerve Block

Approach and Technique

Supinate the arm and place the ultrasound transducer perpendicular to skin.

- G** Visualize the radial nerve distal to the elbow crease and deep to the brachioradialis muscle.



G. Short-axis ultrasound image distal to the elbow demonstrating sonoanatomy relevant to the radial nerve block. BR, brachioradialis muscle; R, radius; N, radial nerve.



- H** After sterile skin preparation and local anesthetic skin infiltration, insert the block needle lateral to the transducer and direct it medially toward the radial nerve.

H. Ultrasound-guided radial nerve block technique employing a high-frequency linear transducer and in-plane needle guidance.

Evaluation of Block

Pinch the base of the index finger, small finger, and dorsum to assess anesthesia in the distribution of median, ulnar, and radial nerves, respectively.

7

US-Guided Subgluteal Sciatic Block

Matthew T. Charous, MD • Larry F. Chu, MD, MS •
Edward R. Mariano, MD, MAS

Patient Position: For subgluteal technique, the patient can be in Sims position or prone with the knee slightly flexed.

Needle Size: 22 to 17-gauge, 70 to 100-mm block needle

Volume: 20 to 40-mL local anesthetic

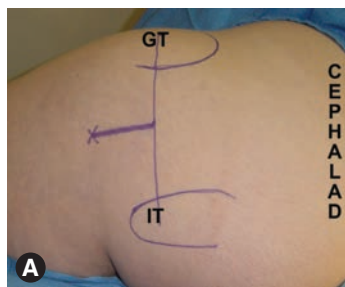
Anatomic Landmarks

- A** Landmarks for the ultrasound-guided subgluteal sciatic nerve block include the greater trochanter (GT) laterally and ischial tuberosity (IT) medially.

Caudal to the gluteal crease, the sciatic nerve lies along the lateral border of the long head of biceps femoris and anterior to the gluteus maximus muscle.

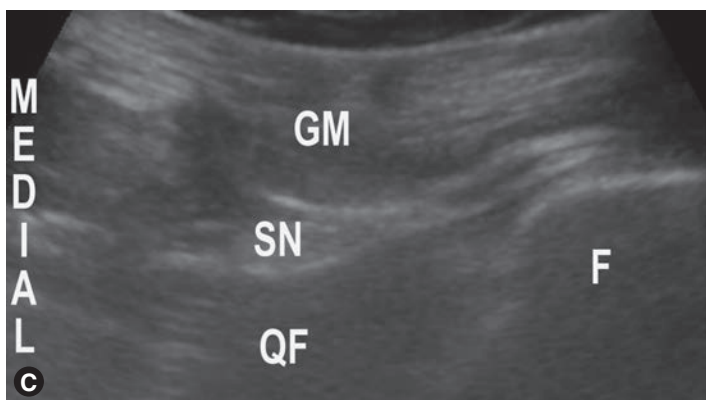
Approach and Technique

- B** With the patient in Sim's position, place the ultrasound transducer perpendicular to skin between the ischial tuberosity and the greater trochanter of the femur caudal to the gluteal crease and oriented parallel to the crease.
- C** The sciatic nerve lies deep to the gluteus maximus muscle between the IT medially and the femur laterally.



A. Surface anatomic landmarks relevant to the classic subgluteal sciatic nerve block. GT, greater trochanter of the femur; IT, ischial tuberosity. **B.** The ultrasound transducer is placed distal to the gluteal crease between the greater trochanter (GT) of the femur and the ischial tuberosity to image the sciatic nerve in cross section. The block needle is inserted lateral to the transducer and directed medially for in-plane needle guidance (left hip shown).

US-GUIDED SUBGLUTEAL SCIATIC BLOCK



C. Short-axis ultrasound image demonstrating the relevant cross-sectional anatomy for the subgluteal sciatic nerve block approach. GM, gluteus maximus muscle; QF, quadratus femoris muscle; F, femur; SN, sciatic nerve.

A local anesthetic skin wheal is raised lateral to the ultrasound transducer after sterile skin preparation. The block needle is inserted through the skin wheal using in-plane guidance in a lateral-to-medial direction toward sciatic nerve.

Evaluation of Block

Motor testing

Test strength of plantar flexion and dorsiflexion of foot to test blockade of posterior tibial and common peroneal nerve. Asking the patient to flex the knee against resistance allows to assess the hamstring motor blockade.

Sensory testing

Decreased temperature and pinprick sensation over the lateral calf and dorsal/plantar surfaces of the foot confirm the appropriate block.

8

US-Guided Popliteal Block

By Sarah J. Madison, MD • Larry F. Chu, MD, MS •
Edward R. Mariano, MD, MAS

Patient Position: Place patient in prone position. Place a towel roll under patient's affected ankle to permit passive flexion of knee and to facilitate identification of surface landmarks. This block may also be performed in the supine position when necessary.

Needle Size: 22 to 17 gauge, 50 to 100 mm block needle

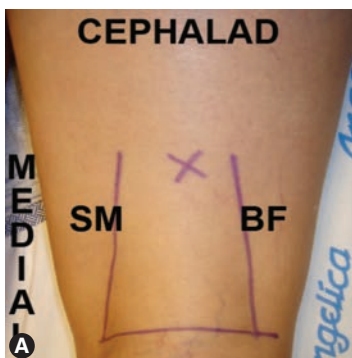
Volume: 20 to 40 mL local anesthetic

Anatomic Landmarks

- A** The popliteal crease is identified and marked while the patient flexes the knee. The medial and lateral borders of popliteal fossa are formed by semimembranosus and biceps femoris tendons. The sciatic nerve is located between these two muscle groups.

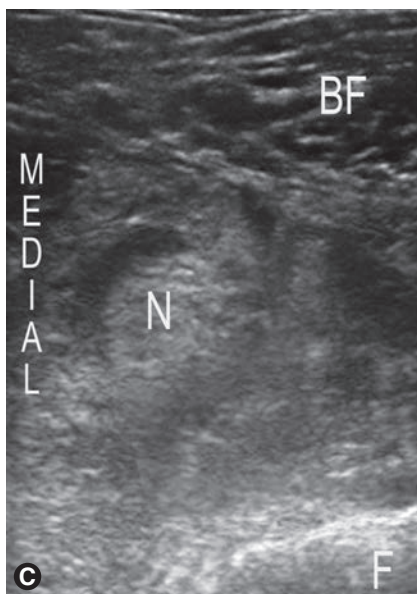
Approach and Technique

- B** With patient in prone position, a high frequency (HF) linear transducer is oriented perpendicular to the long axis of the femur over the intertendinous junction.
- C** Identify the sciatic nerve in short axis anterior and medial to the fascia of biceps femoris muscle, posterior and medial to femur, and posterior to the popliteal vessels when visible.



A. The popliteal fossa is bordered laterally by the biceps femoris tendon and medially by the tendons of semimembranosus and semitendinosus (right popliteal fossa shown). The sciatic nerve is reliably located below the intertendinous junction identified by the "X." **B.** The ultrasound transducer is oriented perpendicular to the long axis of the femur across the intertendinous junction to image the sciatic nerve in cross-section. The block needle is inserted lateral to the transducer and directed medially for in-plane needle guidance (left thigh shown).

US-GUIDED POPLITEAL FOSSA SCIATIC BLOCK



C. Short-axis ultrasound image demonstrating the relevant cross-sectional anatomy for the popliteal sciatic nerve block. RF, biceps femoris muscle; F, femur; N, sciatic nerve.

Trace sciatic nerve proximally and distally from this point to reveal bifurcation of sciatic nerve. Commence block proximal from this point. A local anesthetic skin wheal is raised lateral to the transducer on arterial thigh at a position corresponding to the depth of the sciatic nerve. Insert the block needle through skin wheal using in-plane guidance in a medial direction toward the target nerve. After the needle tip passes through biceps femoris fascia and is positioned near the sciatic nerve, incremental aspiration and injection of local anesthetic solution should result in circumferential spread around the target.

Evaluation of Block

Motor testing

Testing strength of plantar flexion and dorsiflexion of the foot test blockade of the posterior tibial nerve and common peroneal nerve, respectively.

Sensory testing

Decreased temperature and pinprick sensation over lateral calf and dorsal/plantar surfaces of foot confirms appropriate sciatic nerve block.

9

Lumbar Plexus Block

By Jason G. Ramirez, MD • Larry F. Chu, MD, MS •
Edward R. Mariano, MD, MAS

Patient Position: The patient should be placed in the lateral decubitus position with the operative side up. The hips should be flexed with the lower back pushed out towards the practitioner.

Needle Size: 4 to 6 in. insulated needle

Volume: 20 to 40 mL local anesthetic

Anatomic Landmarks

The lumbar plexus block (LPB) is routinely performed at the L₄ vertebral level. A line marking the midline should be drawn in a caudad-cephalad fashion along the spinous processes of the lumbar vertebrae.

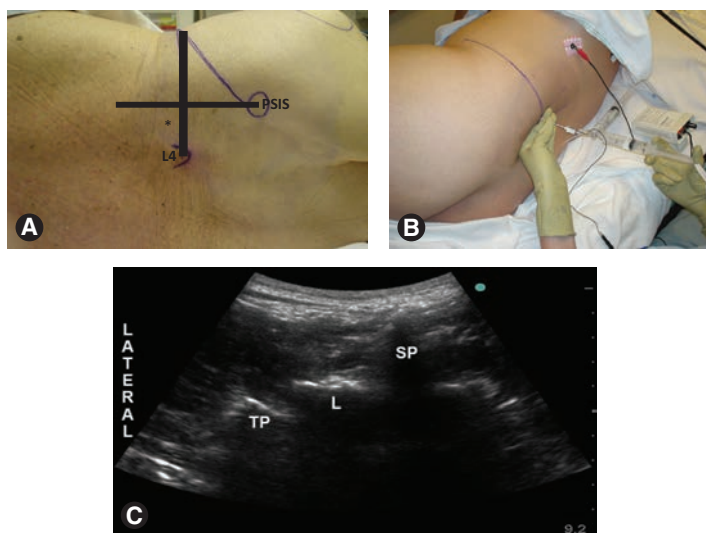
- A** Draw the intercrestal line between the tops of the iliac crests which intersects the midline at a 90 degree angle.
A third line parallel to midline is marked through the posterior superior iliac spine in a cephalad direction to intersect the intercrestal line. The distance between the two intersections is divided into thirds, and the site for needle insertion will be 1 cm cephalad from the junction of the middle and lateral thirds, approximating the location of the L₄ transverse process.

Approach and Technique

- B** After sterile skin preparation and injection of a local anesthetic skin wheal, a 4 to 6 in stimulating needle is advanced perpendicular to the skin.
- C** Prepuncture ultrasound scanning may help practitioners confirm the location and depth of the lumbar transverse processes prior to performing LPB.
The distance from skin to lumbar transverse process is highly variable and dependent on body mass index (BMI) and gender.

However, the distance from transverse process to the lumbar plexus anteriorly is independent of BMI or gender and is fairly constant at approximately 2 to 3 cm. Elicitation of a quadriceps contraction signifies correct needle tip placement within the lumbar plexus.

LUMBAR PLEXUS BLOCK



A. Landmarks for the stimulating LPB include the intercrestal line approximately at the level of L4 and the posterior superior iliac spine (PSIS); * marks the recommended site for needle insertion (5). **B.** Stimulating LPB technique: a 4 to 6 in insulated needle is inserted perpendicular to skin at a puncture site predetermined by surface anatomic landmarks. The intersection of the intercrestal line with the parasagittal line determines the site of introduction of the needle. IS, iliac spine; PSIS, postsuperior iliac spine. **C.** Short-axis ultrasound image at the level of the lumbar vertebra; SP, spinous process; L, lamina; TP, transverse process.

If bony contact with the L4 transverse process is established, the needle is withdrawn, walked caudally off of the transverse process, and then advanced up to 3 cm seeking an evoked motor response of the quadriceps muscle.

Evaluation of Block

The quality of nerve blockade should be evaluated prior to surgical incision even if intra-operative general anesthesia is planned.

Sensory and motor testing of the lumbar plexus can be accomplished using the three “P”s—Pull, Pinch, and Punt.

“Pull” involves abducting the patient’s leg and then asking the patient to move the leg voluntarily toward midline to evaluate the strength of the adductor muscles innervated by the obturator nerve.

The lateral femoral cutaneous nerve is a purely sensory nerve, so a “Pinch” assesses anesthesia in this nerve distribution by pinching the skin over the lateral thigh.

“Punt” involves supporting the patient’s leg under the knee and asking the patient to perform a kicking motion against resistance to test the quadriceps muscle innervated by the femoral nerve.

10

US-Guided Femoral Nerve Block

By Matthew T. Charous, MD • Larry F. Chu, MD, MS • Edward R. Mariano, MD, MAS

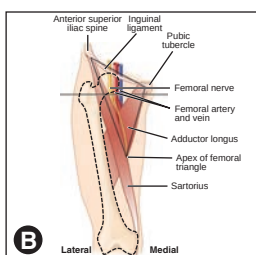
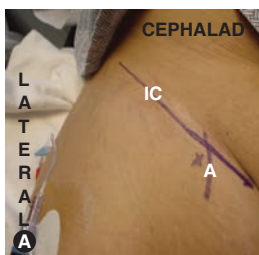
Patient Position: Position the patient supine with a small hip roll under the side to be blocked to flatten the inguinal crease. The leg should be straight and not internally or externally rotated.

Needle Size: 22 to 17 gauge, 50 to 100 mm block needle

Volume: 20 to 40 mL local anesthetic

Anatomic Landmarks

- A** The important landmarks for this block include the inguinal crease and femoral artery (FA).
- B** An anatomic study has shown the femoral nerve (FN) to be widest and most superficial at the level of the inguinal crease where it can be found immediately lateral to the artery 71% of the time.



A. Surface anatomic landmarks relevant to the FN block. IC, inguinal crease; A, femoral artery. An “X” is placed lateral to the FA to identify the site for needle insertion (left inguinal region shown). **B.** Illustration of the relationship of the FN, FA, and femoral vein below the inguinal ligament. Reproduced from Perlas A. Ultrasound Guided Femoral Nerve Block. In: Chelly JE, ed. *Peripheral Nerve Blocks: A Color Atlas*. 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 2009: 295, with permission.

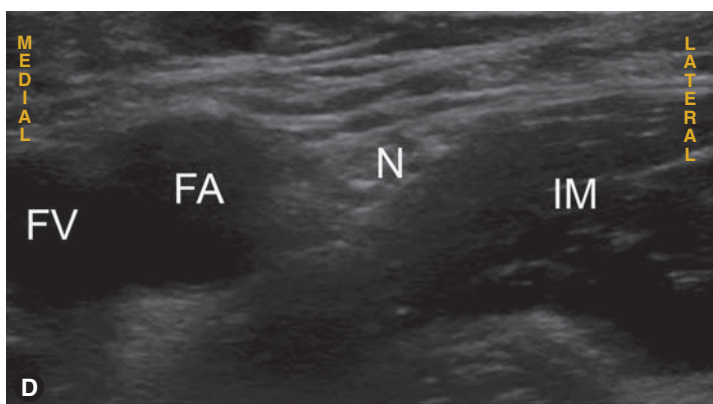


Approach and Technique

- C** With a high frequency linear transducer positioned at the level of the inguinal crease and oriented parallel to the inguinal ligament, the FA is identified.

C. A high frequency linear transducer is placed over the FA pulsation at the level of the inguinal crease. The block needle is inserted lateral to the transducer and directed medially for in-plane needle guidance (left inguinal region shown).

US-GUIDED FEMORAL NERVE BLOCK



D. Short-axis ultrasound image of the femoral vessels and FN at the inguinal crease; FV, femoral vein; FA, femoral artery; IM, iliacus muscle; N, femoral nerve.

- D** If the femoral and profunda femoris arteries are both visible, move the transducer more cephalad until the two vessels merge to form the common FA. At this level, the FN lies lateral to the FA between the fascia iliaca and iliacus muscle. The block needle is inserted through the skin wheal using in-plane guidance in a lateral-to-medial direction toward the FN. Once the needle tip has traversed the fascia iliaca lateral to the FN, local anesthetic is injected incrementally until visual confirmation of injectate spread surrounding the FN is achieved.

Evaluation of Block

Motor testing

Strength of leg extension against resistance or gravity tests the quadriceps muscle innervated by the FN.

Sensory testing

Testing cold temperature and pinprick sensation over the anterior thigh assesses sensory anesthesia in the FN distribution. Similar testing over the lateral thigh assesses anesthesia in the lateral femoral cutaneous nerve distribution.

11

US-Guided Ankle Block

By Matthew T. Charous, MD • Larry F. Chu, MD, MS • Edward R. Mariano, MD, MAS

Patient Position: Position the patient supine (preferred) or prone with the foot to be anesthetized elevated on a roll.

Needle Size: 22-gauge Tuohy-tip or B-bevel block needle

Volume: 5 mL per nerve

Anatomic Landmarks

A Important surface landmarks to identify include the most cephalad portions of the medial malleolus (MM), lateral malleolus (LM), and the Achilles tendon posteriorly. The sural nerve is located in the subcutaneous tissue between the LM and Achilles tendon. Have the patient dorsiflex the great toe to identify the extensor hallucis longus (EHL) tendon. The tendon of tibialis anterior lies medial to the EHL, and the dorsalis pedis artery is typically palpable between these two tendons. The deep peroneal nerve innervates the webspace between the first and second toes. It lies deep to the extensor retinaculum between the two tendons and is closely associated with the dorsalis pedis artery.



A. Anatomic landmarks. From Clanton TO, Loncarich DP. Ankle block. In: Chelly JE. Peripheral nerve blocks: A color atlas. 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 2009: 158, with permission.

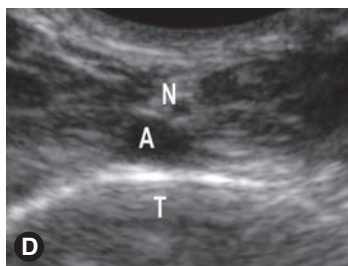
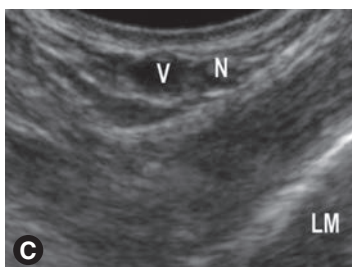
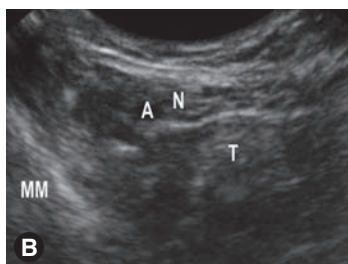
neal nerve innervates the webspace between the first and second toes. It lies deep to the extensor retinaculum between the two tendons and is closely associated with the dorsalis pedis artery.

Approach and Technique

US-Guided Tibial Nerve Block

B Place the transducer cephalad to the MM and image the posterior tibial artery in short axis. The nerve will appear immediately posterior to the artery. Injection of 5 mL of local anesthetic around the nerve will result in reliable anesthesia.

US-GUIDED ANKLE BLOCK



B. Sonoanatomy relevant to the tibial nerve block; MM, medial malleolus; A, posterior tibial artery; N, nerve; T, flexor hallucis longus tendon. **C.** Sonoanatomy relevant to the sural nerve block; LM, lateral malleolus; V, lesser saphenous vein; N, nerve. **D.** Sonoanatomy relevant to the deep peroneal nerve block; T, tibia; A, anterior tibial artery; N, nerve

US-Guided Sural Nerve Block

- C** Using a small linear transducer or small curvilinear transducer, image the lesser saphenous vein in short-axis. Applying a tourniquet proximally helps to distend the lesser saphenous vein and facilitates its identification. Insert the block needle in-plane and deposit up to 5 mL of local anesthetic solution circumferentially around the lesser saphenous vein.

US-Guided Deep Peroneal Nerve Block

- D** Apply the transducer over the anterior tibia at the level of the superior margin of the malleoli. Superficial to the tibial surface, the deep peroneal nerve can be visualized lateral to the anterior tibial artery (continuing as the dorsalis pedis artery distally). Insert the block needle in-plane and deposit up to 5 mL of local anesthetic solution circumferentially around the deep peroneal nerve or lateral to the anterior tibial artery if the nerve cannot be identified.

Evaluation of Block

Blockade of the deep and superficial peroneal nerves may be assessed by testing sensation in the webspace between the first and second toes and over the dorsum of the foot. Testing sensation along lateral and plantar surfaces of the foot will assess anesthesia in the sural and tibial nerve distributions, respectively.

12

US-Guided TAP Block

By Justin W. Heil, MD, PhD • Larry F. Chu, MD, MS •
Matthew T. Charous, MD • Edward R. Mariano, MD, MAS

Patient Position: The patient may be positioned supine (bilateral and/or single-injection transversus abdominis plane [TAP] blocks) or in lateral decubitus (preferred for preoperative TAP catheter placement).

Needle Size: 22–17-gauge Tuohy-tip or B-bevel block needle

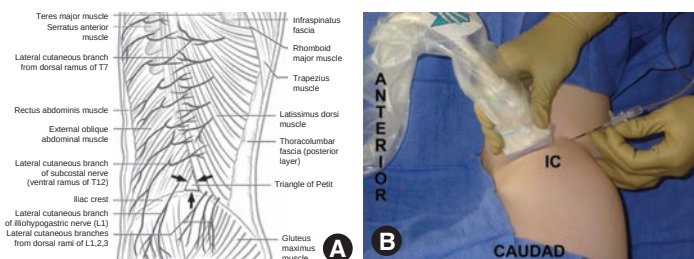
Volume: 20 mL local anesthetic per side

Anatomic Landmarks

- A** The borders of the Triangle of Petit serve as the major surface anatomic landmarks: the iliac crest inferiorly, the external oblique (EO) muscle anteriorly, and the latissimus dorsi muscle posteriorly. A line can be drawn along the costal margin cephalad and the iliac crest caudad on the affected side.

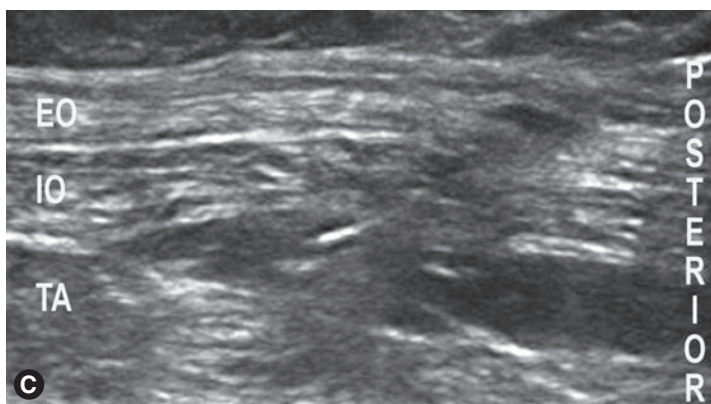
Approach and Technique

- B** A high-frequency linear transducer is oriented anterior/posteriorly on the lateral abdominal wall, cephalad to the iliac crest, along the midaxillary line. The EO, internal oblique (IO), and transversus abdominis (TA) muscles should be visualized.



A. Illustration demonstrating the borders of the triangle of Petit and other relevant anatomic landmarks for the TAP block. Figure reproduced from McDonnell JG, et al. RAPM 2007;32:399-404, Fig. 1, pg. 400, with permission. **B.** The ultrasound transducer is positioned cephalad to the iliac crest, oriented anterior-posterior, and slightly anterior to the mid-axillary line to image the abdominal wall layers in short axis. For preoperative ultrasound-guided TAP catheter insertion, the patient is positioned lateral decubitus, and the needle is inserted posterior to the transducer and directed anteriorly toward the target layer.

US-GUIDED TAP BLOCK



C. Short-axis ultrasound image demonstrating the relevant cross-sectional anatomy for the TAP block. EO, external oblique muscle; IO, internal oblique muscle; TA, transversus abdominis muscle.

A skin wheal with local anesthetic is raised at the site of planned needle insertion.

The block needle is inserted through this skin wheal using in-plane guidance and directed through the EO and IO. A “pop” may be felt and observed under ultrasound as the needle tip passes through into the plane between the IO and TA.

- C** Local anesthetic is injected incrementally until visual confirmation of a discrete, elliptical fluid deposit is confirmed.
If intramuscular injectate is detected, advance or withdraw the needle until the tip is positioned within the TAP.

Evaluation of Block

Sensory testing can be performed by checking for loss of sensation to cold or pinprick in the target dermatomes of the planned surgical procedure.

A single-injection TAP block with 20 mL local anesthetic should be expected to anesthetize the ipsilateral T10-L1 dermatomes.

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US-Guided Paravertebral Block

By Justin W. Heil, MD, PhD • Larry F. Chu, MD, MS • Edward R. Mariano, MD, MAS

Patient Position: Position patient sitting with neck flexed or prone. If unable to place in a sitting position, the prone position is preferred.

Needle Size: 22-gauge, Tuohy-tip block needle

Volume: 5 mL local anesthetic per paravertebral space

Anatomic Landmarks

A Mark a 2.5 cm point lateral to each spinous process.

Approach and Technique

B Out-of-plane needle guidance: Apply transducer perpendicular to skin in a parasagittal plane 2 cm lateral to the midline and parallel to the spine. Insert the block needle perpendicular to the skin after injecting a local anesthetic skin wheal and advance the needle out-of-plane toward the paravertebral space. When the needle tip passes the superior costotransverse ligament (thoracic) or the desired depth is achieved (~ 1 cm past the transverse process for thoracic; 0.5 cm past the transverse process for lumbar), inject 5 mL of local anesthetic solution after negative aspiration for blood. Repeat process for each level.



A. When performing out-of-plane thoracic paravertebral block, identify the spinous processes of the vertebrae representing the desired dermatomal levels of anesthesia. Approximate sites for needle insertion are then marked 2.5 cm lateral to each spinous process over the transverse process of the vertebra one level caudad. **B.** Transducer positioning and needle insertion technique during out-of-plane ultrasound-guided paravertebral block.

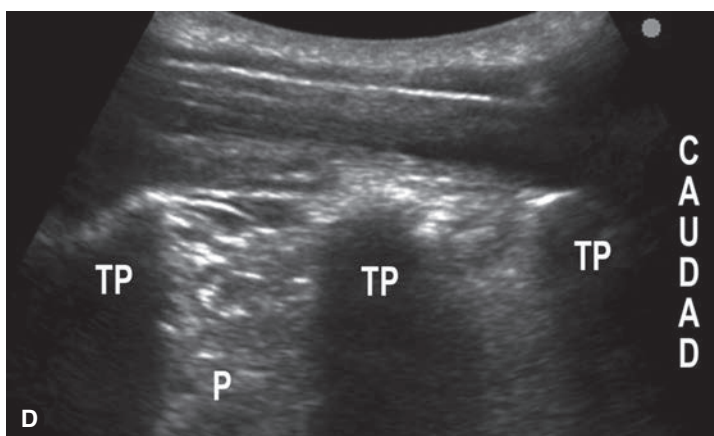
C In-plane needle guidance: Apply the transducer perpendicular to the skin in a parasagittal plane 2 cm lateral to the midline and parallel to the spine.

US-GUIDED PARAVERTEBRAL BLOCK



C. Transducer positioning and needle insertion technique during in-plane ultrasound-guided paravertebral block.

- D** Identify the TP of the vertebral bodies cephalad and caudad to the target paravertebral space and the pleura anteriorly. Inject a local anesthetic skin wheal caudad to the ultrasound transducer, and insert the block needle through the wheal directed in-plane toward the paravertebral space. When the needle tip is visualized within the target space, inject 5 mL of local anesthetic solution after negative aspiration for blood. Repeat this process for each level.



D. Ultrasound image of the paravertebral space. TP, transverse process; P, pleura.

Evaluation of Block

The quality and extent of nerve blockade must be evaluated prior to surgical incision even if intraoperative general anesthesia is planned. Sensory testing can be performed by checking for loss of sensation to cold or pinprick in the distribution of the desired dermatomes.

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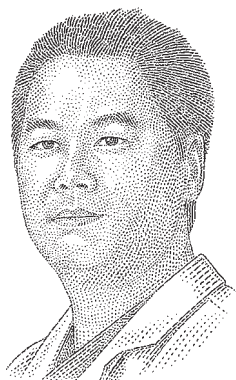
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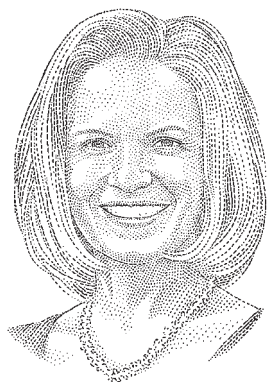
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Preface



Larry F. Chu, MD, MS



Andrea J. Fuller, MD

We designed *Point of Care Essentials* to be used by practicing anesthesiologists during perioperative procedures and treatments. **It is not a textbook of anesthesiology.** There are already many excellent texts that provide detailed explanations of the principles and practice of perioperative medicine. These cards are a companion to the *Manual of Clinical Anesthesiology* and are not intended to be used as a sole source of information about any topic, procedure, or process in anesthesiology.

These cards are a set of **cognitive aids** designed to guide the practitioner through a series of steps necessary to complete a process or procedure. We anticipate that it may be necessary for practitioners who are unfamiliar with certain procedures to reference other anesthesia texts, such as the *Manual of Clinical Anesthesiology*, for additional information.

We have designed these cards to appeal to today's highly visual learners by incorporating full-color graphics, illustrations, and photographs. We believe the spiral-bound and laminated format of *Point of Care Essentials* creates a highly portable reference that brings practical information where it is needed most: in the operating room, on the wards, and at the patient bedside.

Larry F. Chu and Andrea J. Fuller,
Editors-in-Chief

Crisis Management Cognitive Aids

How to Use Cognitive Aids in Crisis Management

The use of cognitive aids to manage crises in anesthesia is controversial. The goal of these cognitive aids is to provide a reference for the management of certain clinical conditions and emergency situations.

The use of cognitive aids should not replace individual clinical judgment and may not be applicable to all clinical situations.

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Major portions of this text were developed by the Stanford Anesthesia Informatics and Media Lab, specifically the visual atlases and cognitive aids. We would like to recognize these important contributors to this book.

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PULSELESS ELECTRICAL ACTIVITY

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS • T. Kyle Harrison, MD



CPR:

1. ≥ 100 compressions/minute
2. Minimize breaks in CPR

CALL FOR HELP



CODE CART

CHECK

Always Check:

1. Backboard
2. Establish airway
3. IV access (consider IO)
4. Monitor for rhythm changes
5. If shockable rhythm (VF/VT), defibrillate

In the OR:

1. Turn **OFF** volatile
2. 100% O₂
3. Check ventilation rate (**8 breaths/minute**)
4. Consider: Local Anesthetic Toxicity, Malignant Hyperthermia, Autopeep, Anaphylaxis

TREATMENT

1. **Epinephrine** - 1 mg IV push q 3–5 minutes
2. Consider: **Vasopressin** - 40 units IV (x1, could replace one specific epinephrine dose)

DIAGNOSIS

Search for Treatable Causes

H's:

1. Hypovolemia
2. Hypoxia
3. Hydrogen ions - acidosis
4. Hyper- or Hypokalemia
5. Hypo- or Hyperthermia
6. Hypoglycemia or Hypocalcemia

T's:

7. Toxins (overdose)
8. Tamponade - cardiac
9. Tension pneumothorax
10. Thrombosis coronary
11. Thrombosis pulmonary

FIND AND TREAT CAUSE: H & T's

FOR ASYSTOLE AND PULSELESS ELECTRICAL ACTIVITY

TREATMENT

1. **Hypovolemia:** Administer rapid bolus of IV fluid and check hemoglobin/hematocrit. Give blood for anemia or massive hemorrhage.
2. **Hypoxia:** 100% FiO₂. Confirm oxygen connections. Check for bilateral breath sounds. Suction ET tube and reconfirm ET tube placement. Consider chest x-ray.
3. **Hydrogen ion (acidosis):** Check blood gas for acidosis. Administer sodium bicarbonate. Consider increasing ventilation rate (this will decrease effectiveness of CPR).
4. **Hyperkalemia:** Check blood gas for electrolyte abnormalities. Give Calcium Chloride 1 g IV; D50 1 Amp IV (25 g Dextrose) + Regular Insulin 10 units IV (monitor glucose). **Hypokalemia:** Rapid but controlled infusion of potassium & magnesium.
5. **Hypothermia:** Active warming by forced air blanket, warm IV. Consider cardiopulmonary bypass. **Hyperthermia:** Cool with axillary ice packs, cold IV. Consider peritoneal lavage. If anesthetic exposure, consider Malignant Hyperthermia. Call for MH Cart. Treat with dantrolene. MH Hotline: 800-644-9737 (MH-Hyper).
6. **Hypoglycemia or Hypocalcemia:** Check blood gas or finger stick.
7. **Toxins:** Consider overdose of medication. Confirm no infusions are running. Confirm volatile anesthetic off.
8. **Tamponade (Cardiac):** Consider placing transesophageal (TEE) or transthoracic (TTE) echo to rule out. Treat with pericardiocentesis.
9. **Tension Pneumothorax:** Unilateral breath sounds, possibly distended neck veins and deviated trachea (late signs). Perform emergent needle decompression (2nd intercostal space at mid-clavicular line) followed by chest tube placement. Call for chest x-ray, but do not delay treatment.
10. **Thrombosis (Myocardial Infarction):** Consider using TEE to evaluate wall motion of ventricle. Consider emergent coronary revascularization or fibrinolytic agents.
11. **Thrombosis (Pulmonary Embolus):** Consider TEE to evaluate right ventricle. Consider fibrinolytic agents.

VENTRICULAR TACHYCARDIA & VENTRICULAR FIBRILLATION

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS • T. Kyle Harrison, MD

V-TACH:



V-FIB:



CPR:

1. ≥ 100 compressions/minute
2. Minimize breaks in CPR

CALL FOR HELP



CODE CART

WHEN IT ARRIVES: DEFIBRILLATE!

CHECK

Always Check:

1. Backboard
2. Establish airway
3. IV Access

In the OR:

1. Turn **OFF** volatile
2. 100% O₂
3. Check vent rate (**8 breaths/min**)
4. Do not overventilate

TREATMENT

DEFIBRILLATE: 200 Joules (biphasic)

RESUME CPR IMMEDIATELY

EPINEPHRINE: 1 mg IV push q 3–5 minutes **OR**

VASOPRESSIN: 40 units IV push once

REPEAT CYCLE OF CPR, DEFIB, & MEDS!

CONSIDER

Consider Antiarrhythmics: Amiodarone 300 mg IV
Lidocaine 100 mg IV

If HypoMg or Torsades: Magnesium sulfate 2 grams IV

If HyperK: Calcium, insulin & glucose, sodium bicarbonate

ASYSTOLE

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS • T. Kyle Harrison, MD

FLAT LINE:



CPR:

1. ≥ 100 compressions/minute
2. Minimize breaks in CPR

CALL FOR HELP



CODE CART

CHECK

Always Check:

1. Backboard
2. Establish airway
3. IV access (consider IO)
4. Monitor for rhythm changes
5. If shockable rhythm (VF/VT), defibrillate

In the OR:

1. Turn **OFF** volatile
2. 100% O₂
3. Check vent rate (**8 breaths/minute**)
4. Consider: Local Anesthetic Toxicity, Malignant Hyperthermia, Autopeep, Anaphylaxis

TREATMENT

1. **Epinephrine** - 1 mg IV push q 3–5 minutes
2. Consider: **Vasopressin** - 40 units IV (x1, could replace one specific epinephrine dose)

DIAGNOSE

Search for Treatable Causes

H's:

1. Hypovolemia
2. Hypoxia
3. Hydrogen ions - acidosis
4. Hyper- or Hypokalemia
5. Hypo- or Hyperthermia
6. Hypoglycemia or Hypocalcemia

T's:

7. Toxins (overdose)
8. Tamponade - cardiac
9. Tension pneumothorax
10. Thrombosis coronary
11. Thrombosis pulmonary

FIND AND TREAT CAUSE: H & T's

FOR ASYSTOLE AND PULSELESS ELECTRICAL ACTIVITY

TREATMENT

1. **Hypovolemia:** Administer rapid bolus of IV fluid and check hemoglobin/hematocrit. Give blood for anemia or massive hemorrhage.
2. **Hypoxia:** 100% FiO₂. Confirm oxygen connections. Check for bilateral breath sounds. Suction ET tube and reconfirm ET tube placement. Consider chest x-ray.
3. **Hydrogen ion (acidosis):** Check blood gas for acidosis. Administer sodium bicarbonate. Consider increasing ventilation rate (this will decrease effectiveness of CPR).
4. **Hyperkalemia:** Check blood gas for electrolyte abnormalities. Give Calcium Chloride 1 g IV; D50 1 Amp IV (25 g Dextrose) + Regular Insulin 10 units IV (monitor glucose). **Hypokalemia:** Rapid but controlled infusion of potassium & magnesium.
5. **Hypothermia:** Active warming by forced air blanket, warm IV. Consider cardiopulmonary bypass. **Hyperthermia:** Cool with axillary ice packs, cold IV. Consider peritoneal lavage. If anesthetic exposure, consider Malignant Hyperthermia. Call for MH Cart. Treat with dantrolene. MH Hotline: 800-644-9737 (MH-Hyper).
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10. **Thrombosis (Myocardial Infarction):** Consider using TEE to evaluate wall motion of ventricle. Consider emergent coronary revascularization or fibrinolytic agents.
11. **Thrombosis (Pulmonary Embolus):** Consider TEE to evaluate right ventricle. Consider fibrinolytic agents.

BRADYCARDIA - UNSTABLE

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

1. CHECK FOR PULSE

- If NO pulse, go to PEA algorithm.
- If pulse present but hypotensive, proceed with treatment.

CALL FOR HELP



CODE CART

INFORM SURGEON

TREATMENT

1. Increase **FiO₂** **100%**.
2. Confirm adequate **ventilation** and **oxygenation**.
3. Consider turning down or **OFF** all anesthetics.
4. **Atropine**: 0.4 to 1.0 mg IV, may repeat up to 3 mg. Consider infusions below.
5. Consider transcutaneous **pacing**:
 - Set rate to at least 80 bpm.
 - Increase current until capture achieved.
 - Confirm patient has pulse with capture.

SECONDARY

1. Place **arterial line**.
 2. Send **labs**: ABG, hemoglobin, electrolytes.
 3. Rule out **ischemia**: Consider EKG, troponins.
- Consider Infusions**
1. **Dopamine**: 5 to 20 mcg/kg/min.
 2. **Epinephrine**: 2 to 10 mcg/min.
 3. **Isoproterenol**: 2 to 10 mcg/min.

AMNIOTIC FLUID EMBOLISM

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

Consider amniotic fluid embolism if there is the sudden onset of the following in a pregnant or post-partum patient:

1. Respiratory distress, decreased O_2 saturation
2. Cardiovascular collapse: hypotension, tachycardia, arrhythmias, cardiac arrest
3. Coagulopathy
4. Disseminated intravascular coagulation (DIC)
5. Seizures
6. Altered mental status

INFORM SURGEON



CALL FOR HELP

TREATMENT

1. Administer **100% O_2** .
2. **Consider/prepare for emergent intubation.**
3. Place patient in left uterine displacement (LUD).
4. Establish **IV access** (large volume lines).
5. Consider placing **invasive monitoring** (arterial line).
6. Anticipate possible **cardiopulmonary arrest** and **emergent C-section.**
7. Anticipate the **development of DIC.**
8. Support circulation with **IV fluid, vasopressors, and inotropes.**
9. Consider **circulatory support:** IABP/ECMO/CPB.

RULE OUT

Rule out other causes that might present in a similar fashion:

- | | |
|-----------------|---|
| 1. Eclampsia | 6. Pulmonary embolism |
| 2. Hemorrhage | 7. Anesthetic overdose |
| 3. Air embolism | 8. Sepsis |
| 4. Aspiration | 9. Cardiomyopathy/cardiac valvular abnormality/MI |
| 5. Anaphylaxis | |

DIFFICULT AIRWAY

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

If unsuccessful after initial attempt at direct laryngoscopy (DL):

1. Attempt to reposition patient's head to improve "sniffing position"
2. Change to a different laryngoscope blade
3. Consider placing towels under the patient's shoulders to align the tragus of the ear with the sternal notch

If grade II or III view attempt to place gum elastic bougie then pass ET tube over bougie, confirm with ETCO₂ and bilateral breath sounds.

Attempt face mask ventilation, maintain cricoid pressure if rapid sequence induction

UNSUCCESSFUL

SUCCESSFUL

CALL FOR HELP!
PLACE ORAL, NASAL
AIRWAY

SEE NEXT PAGE

UNSUCCESSFUL

Place LMA

SUCCESSFUL

CONSIDER:

1. Awakening patient
2. Doing the case with LMA
3. LMA as a conduit for intubation
4. +/- fiber optic guidance

UNSUCCESSFUL

Emergency Airway Ventilation

If ventilation becomes inadequate

CALL FOR HELP

Attempt: Needle cricothyrotomy
Percutaneous cricothyrotomy
Transtacheal Jet Ventilation
Tracheostomy

Confirm successful placement with ETCO₂ and bilateral breath sounds.

DIFFICULT AIRWAY

Continued from previous page

IF SUCCESSFUL face mask ventilation, attempt 3rd DL after changing position/blade again if needed. Consider external pressure on the anterior neck/larynx.

- Move left/right, push down and up on larynx.
- Briefly release cricoid pressure may improve view of glottic structure.

UNSUCCESSFUL

Attempt face mask ventilation, maintain cricoid pressure if rapid sequence induction

SUCCESSFUL

CONSIDER:

1. Awakening patient
2. Completing case with LMA or face mask ventilation
3. Fiber optic intubation
4. Intubating LMA
5. Using LMA as a conduit for intubation +/- fiber optic guidance
6. Light wand
7. Retrograde wire intubation
8. Blind nasal intubation

UNSUCCESSFUL

CALL FOR HELP!
PLACE ORAL, NASAL
AIRWAY

SEE PREVIOUS PAGE

If ventilation becomes inadequate

Place LMA (see previous page)

Modified from: Practice Guidelines for the Management of Difficult Airway. *Anesthesiology*, 2003.

MALIGNANT HYPERTHERMIA

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

EARLY:

1. Increased ETCO_2
2. Tachycardia
3. Tachypnea
4. Acidosis
5. Masseter spasm/trismus

LATE:

1. Hyperthermia
2. Trunk/limb rigidity
3. Myoglobinuria

INFORM SURGEON



CALL FOR HELP

CALL FOR MH CART • START PREPARING DANTROLENE!

RULE OUT

- Light anesthesia
- Hypoventilation
- Over-heating (external)
- Thyroid storm
- Pheochromocytoma
- Hypoxemia

TREATMENT

1. **Discontinue** anesthetic triggers (volatiles and succinylcholine) and **increase** fresh gas flow to 10 L/min. Do NOT change machine or circuit.
2. Convert to TIVA for maintenance.
3. **Hyperventilate**, FiO_2 100%, high flow O_2 .
4. **Prepare 2.5 mg/kg IV Dantrolene bolus**. Dilute each 20 mg Dantrolene vial in 60 mL **sterile water**.
5. **Rapidly administer dantrolene**. Continue giving until patient stable (may give up to 10 mg/kg).
6. **Administer** sodium bicarbonate 1–2 mEq/kg for metabolic acidosis/hyperkalemia.

MALIGNANT HYPERTHERMIA

Continued from previous page

TREATMENT

7. Actively **cool patient** with ice packs and cold saline lavage.
8. Arrhythmias are usually secondary to hyperkalemia: **treat** with insulin/glucose, sodium bicarbonate and/or calcium chloride. **Avoid calcium channel blockers.**
9. Send labs for ABG, CPK, myoglobin, PT/PTT, and lactic acid.

SECONDARY

Once successfully treated, monitor the patient for 36 hours in the intensive care unit. The patient should continue to receive **1 mg/kg dantrolene every 6 hours for 36 hours.**

Contact the Malignant Hyperthermia Association of the United States (MHAUS) at any time for consultation if MH is suspected: 1-800-986-4287, or online at <http://www.mhaus.org/>.

ANAPHYLAXIS

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

Some signs may be absent in an anesthetized patient:

1. Hypoxemia, difficulty breathing, tachypnea
2. Rash/hives
3. Hypotension (may be severe)
4. Tachycardia
5. Bronchospasm/wheezing/hypoxemia
6. Increase in peak inspiratory pressure (PIP)
7. Angioedema (potential airway swelling)

INFORM SURGEON



CALL FOR HELP

PREPARE EPINEPHRINE 10 mcg/mL OR 100 mcg/mL

If patient becomes pulseless, start CPR, continue Epinephrine 1 mg IV boluses, large volume IVF, and switch to PEA algorithm

RULE OUT

Consider and rule out other causes:

- Pulmonary embolus
- Myocardial infarction
- Anesthetic overdose
- Pneumothorax
- Hemorrhage
- Aspiration

ANAPHYLAXIS

Continued from previous page

TREATMENT

1. **Discontinue potential allergens: colloid solutions, blood products, latex products, antibiotics.**
2. **Discontinue volatile anesthetic** if hypotensive.
3. **Increase FiO_2** to 100%.
4. **Administer IV fluid bolus.** May require many liters!
5. **Administer epinephrine** IV in escalating doses every two minutes. Start at 10-100 mcg IV and increase dose every 2 minutes until clinical improvement is noted. May require large doses > 1 mg.
6. **Consider vasopressin** (start with 2–4 units IV).
7. Treat **bronchospasm** with **albuterol** and **epinephrine** (if severe).
8. Give **H₁ antagonist** (e.g. Diphenhydramine 25–50 mg IV).
9. Consider **corticosteroids** (e.g. Methylprednisolone 125 mg IV) to decrease bi-phasic response.
10. Consider **early intubation** to secure airway **prior to** development of **angioedema** of airway.
11. Consider **additional IV access** and **invasive monitors** (arterial line).

POST EVENT

Consider the following interventions following the event:

1. Send serum tryptase level (can be added for 6 hrs post-event)
2. If the event was moderate to severe, consider keeping patient intubated and sedated.
3. Refer the patient for postoperative allergy testing.
4. Can recur with biphasic response: Consider monitoring patient for 24 hours post-recovery.

MYOCARDIAL ISCHEMIA

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

Suspect myocardial ischemia if:

- Depression or elevation of **ST segment** from the isoelectric level.
- **Arrhythmias**, conduction abnormalities, **unexplained tachycardia, bradycardia, or hypotension.**
- Elevation of cardiac filling pressures
- Regional wall motion abnormalities or new onset mitral regurgitation on TEE.
- In the **awake patient** signs and symptoms may include: central chest pain radiating into the arms or throat, dyspnea, nausea and vomiting, heartburn, and/or altered level of consciousness.

INFORM SURGEON



CALL FOR HELP

MYOCARDIAL ISCHEMIA

Continued from previous page

TREATMENT

1. Increase FiO_2 to **100%**.
2. Verify ischemia with 12 lead EKG if possible.
3. Consult cardiology- stat.
4. Treat hypotension or hypertension.
5. Slow heart rate with **beta-blocker** (esmolol or metoprolol). Hold for bradycardia or hypotension.
6. Consider **nitroglycerin** infusion (hold for hypotension).
7. Treat pain with narcotics (fentanyl or morphine).
8. Consider rectal or PO or NG/OG **aspirin**.
9. Place arterial line.
10. Check hematocrit/hemoglobin and treat anemia with packed red blood cells.
11. Consider central venous access.
12. Consider TEE for monitoring volume status and regional wall motion abnormalities.
13. Send ABG, hematocrit/hemoglobin, CK and troponin.
14. If hemodynamically unstable, consider intra aortic balloon pump.

Be Prepared for Arrhythmias
Consider Code Cart at Bed Side

HYPOTENSION

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS •
Geoff Lighthall, MD • T. Kyle Harrison, MD

SIGNS

1. Feel for **pulse**.
2. Check **heart rate**: if slow, treat and go to bradycardia cognitive aid.
3. Check **rhythm**: if abnormal, go to ACLS Protocol.

INFORM SURGEON



CALL FOR HELP

INSPECT SURGICAL FIELD FOR BLOOD LOSS OR MANIPULATION

TREATMENT

1. Give **IV fluid** bolus.
2. Give **phenylephrine** or **ephedrine** to temporize.
3. Consider **Trendelenberg** or elevation of patient's legs.
4. Turn down or off **anesthetic agent**.
5. Consider **100% O₂**.
6. Consider code cart if severe.

RULE OUT

Consider and rule out other causes that might present in a similar fashion to hypotension:

1. Pneumothorax: listen to breath sounds.
2. Auto-PEEP: disconnect and reconnect circuit.
3. Hemorrhage: rule out occult blood loss.
4. Rule out anaphylaxis.

HYPOTENSION

Continued from previous page

SECONDARY

1. More **IV access**.
2. Call for **rapid infuser**.
3. Call for **blood**.
4. Place **arterial line**.
5. Send **labs**: ABG, Hgb, electrolytes, calcium, type & cross.
6. Consider **terminating surgical procedure** or get surgical help.
7. Consider **transesophageal echo** if unclear cause.
8. **Foley catheter** if not present.
9. Consider **hydrocortisone**.

DDX

MAP = CO x SVR; CO = SV x HR

SV from preload, afterload, contractility

1. **Decreased preload**
2. **Low SVR**
3. **Decreased Contractility**
4. **Low HR**
5. **Increased afterload**
6. **Low Stroke Volume**

HEMORRHAGE/MASSIVE TRANSFUSION

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS • T. Kyle Harrison, MD

INFORM SURGEON



CALL FOR HELP

TREATMENT

1. **Increase FiO_2 to 100%.**
2. **Treat hypotension with IV fluid bolus.**
3. Consider **Trendelenberg** or **elevation of patient's legs.**
4. Call for **rapid infuser.**
5. Establish **additional IV access** as needed.
6. Use **vasopressors** (ephedrine, phenylephrine, epi) as **temporizing measure.** Consider accepting lower blood pressures until bleeding is controlled.
7. Mobilize blood bank to **prepare multiple units of pRBC** and begin to **prepare FFP, platelets, and cryoprecipitate.**
8. **Use O-negative blood** if patient **does not have type and crossed** units available. Use type and crossed units once available unless >10 units of O-negative blood have been given. If this has occurred, then continue with O-negative blood products (or use O+ in males).
9. **Maintain normothermia!** Use fluid warming devices for IV and blood products.
10. Place **arterial line** as indicated.
11. Follow patient's acid/base status by **ABG as indicator of adequate resuscitation. Monitor for hypocalcemia.**

HEMORRHAGE/MASSIVE TRANSFUSION

Continued from previous page

TREATMENT

As resuscitation continues: replace coagulation factors, platelets, fibrinogen as indicated by laboratory values **OR** when greater than 1-1.5X blood volumes have been replaced and laboratory values cannot be measured in a timely fashion.

CONSIDER EARLY REPLACEMENT!

COMPONENTS

PLATELETS: Transfuse for <50K or <50-100K with signs of ongoing bleeding. Dose: 1 pack per 10 kg body weight.

FRESH FROZEN PLASMA: Transfuse for INR (PT) or PTT >1.5X normal with signs of ongoing bleeding. Dose: 10-15 cc FFP per kg body weight.

CRYOPRECIPITATE: Transfuse for fibrinogen <80-100 mg/dL. Dose: 1 unit per 10 kg body weight.

VOLUMES

Estimated Blood Volume (EBV)

Adults: 7% total body weight (~5 L for 70 kg)

Children 9% total body weight

Infants 10% total body weight

EST. LOSS

$$\text{Est. Blood Loss} = \text{EBV} \times \frac{\text{HCT}_{\text{starting}} - \text{HCT}_{\text{measured}}}{\text{HCT}_{\text{starting}}}$$

VENOUS AIR EMBOLUS

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

OBSERVE SUDDEN:

- Decrease in blood pressure and ETCO_2 .
- Decrease in SaO_2 .
- Rise in CVP.
- Onset of dyspnea and respiratory distress in awake patient.
- Increase in ETN_2O (if monitoring).

INFORM SURGEON



CALL FOR HELP

FLOOD SURGICAL FIELD WITH SALINE

TREATMENT

1. Go to 100% O_2 .
2. Give rapid fluid bolus to increase CVP.
3. Turn down or off volatile anesthetic.
4. If possible, place patient in left lateral decubitus position and surgical site below heart.
5. Administer epi to maintain cardiac output.
6. If pulseless, start CPR.
7. Attempt to aspirate air from central line if present.
8. Consider TEE to assess RV function.
9. If severe event, terminate procedure if possible.
10. Monitor patient post operatively in ICU.

TOTAL SPINAL ANESTHESIA

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

AFTER NEURAXIAL ANESTHESIA BLOCK

1. Unexpected rapid rise in sensory levels
2. Numbness or weakness in upper extremities
3. Dyspnea
4. Bradycardia
5. Hypotension
6. Loss of consciousness
7. Apnea
8. Cardiac arrest

Most often occurs with dosing an epidural that has inadvertently become intrathecal.

INFORM SURGEON



CALL FOR HELP

TREATMENT

1. Support ventilation and intubate trachea if necessary.
2. Support blood pressure with IV fluid bolus and vasopressors (may require epinephrine/vasopressin).
3. Treat bradycardia with atropine but quickly move to epinephrine if patient is unstable.
4. If it is an OB patient, monitor fetal heart sounds, and prepare for possible emergent C-section.

LOCAL ANESTHETIC TOXICITY

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

- | | |
|--------------------------|----------------------------|
| 1. Tinnitus | 5. Bradycardia |
| 2. Altered mental status | 6. Ventricular arrhythmias |
| 3. Seizures | 7. Cardiovascular collapse |
| 4. Hypotension | |

CALL FOR HELP



CODE CART

TREATMENT

1. Stop local anesthetic injection and/or infusion.
2. Establish airway - ensure adequate ventilation and oxygenation. Consider endotracheal intubation.
3. Treat seizure activity with **propofol** (only if no hypotension) or **benzodiazepine**.
4. Monitor for hemodynamic instability - treat hypotension.

**If cardiovascular collapse occurs,
start CPR and proceed with ACLS cognitive aid**



**Rapidly administer 20% lipid emulsion IV
1.5 cc/kg rapid bolus then start infusion at 0.25 cc/kg/min
May repeat loading dose (max 3 total doses) and may
increase infusion (max dose 12 cc/kg)**

SECONDARY

1. May require a prolonged resuscitation.
2. If refractory, consider cardiopulmonary bypass if available.
3. Monitor the patient post operatively in the ICU.

TRANSFUSION REACTIONS

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

In patients receiving blood products, monitor for the following signs that could indicate a possible transfusion reaction.

SIGNS

Hemolytic Reaction

1. Tachycardia
2. Tachypnea
3. Hypotension
4. Disseminated Intravascular Coagulation
5. Dark Urine

Febrile

1. Fever

Anaphylactic

1. Tachycardia
2. Wheezing
3. Urticaria/
Hives
4. Hypotension

INFORM SURGEON



CALL FOR HELP

TREATMENT

1. Stop transfusion. Save product for testing in blood bank.
2. Support blood pressure with IV fluids and vaso active medications if needed.
3. If severe **anaphylactic reaction** switch to anaphylaxis cognitive aid.
4. Consider antihistamine.
5. For **hemolytic reaction**, maintain urinary output with IV fluids, diuretics, renal dose dopamine.
6. Monitor for and treat disseminated intravascular coagulation if **hemolytic reaction**.
7. Monitor for lung injury and treat accordingly, may require post operative ventilation.

HYPOXEMIA

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS •
Geoff Lighthall, MD • T. Kyle Harrison, MD

INFORM SURGEON



CALL FOR HELP

TREATMENT

If low O_2 saturation, paO_2 , or blue patient:

1. **100% O_2** with high flows.
2. Check gas analyzer to **rule out low FiO_2** or **high N_2O** . If concerned, go to oxygen failure cognitive aid.
3. Check other **vitals** (cycle NIBP) and PIP.
4. Check for **$ETCO_2$** (? extubated, disconnected, low BP).
5. Check surgical field and **feel for pulse**.
6. **Hand-ventilate** to check compliance/ leaks and decrease machine factors.
7. Listen for **breath sounds** (bilateral or clear).
8. **Soft suction** via ETT (to clear secretions and check obstructions).
9. Consider **Code Cart** if severe.
10. Consider **artifact** last (switch pulse ox machine or location).

CONSIDER

1. Nebulizers to **bronchodilate**- Arterial Blood Gas (ABG) - CXR.
2. Fiberoptic to **confirm ETT position** & check for mucus plugging.
3. **Additional neuromuscular blockade** if intubated and fighting ventilator.
4. Large recruitment breaths by **manual ventilation** (if ? atelectasis and patient not hypotensive).
5. **Artifacts**: check waveform, probe position, ambient light, cautery, dyes, location of probe, check ABG if still unclear.
6. Consider **terminating surgery**.
7. Plan for **postop care**: remain intubated? ICU bed?

DDX

1. Hypoventilation
2. Low FiO_2
3. V/Q mismatch or shunt
4. Diffusion problem
5. Artifacts

PNEUMOTHORAX

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

1. Increased peak inspiratory pressures
2. Tachycardia
3. Hypotension
4. Hypoxemia
5. Decreased breath sounds
6. Hyper resonance of chest to percussion
7. Tracheal deviation (late sign)
8. Increased JVD/CVP
9. Have **high index of suspicion** for pneumothorax in **trauma patients** and **COPD patients**.

INFORM SURGEON



CALL FOR HELP

TREATMENT

1. **DO NOT WAIT FOR X-RAY TO TREAT IF HEMODYNAMICALLY UNSTABLE.**
2. Increase FiO_2 to 100%.
3. Rule out mainstem intubation.
4. Notify surgeon, call for stat portable CXR.
5. Hemodynamically unstable patients should have needle decompression or chest tube placed prior to CXR.
6. Place 14 or 16 gauge needle mid clavicular line 2nd intercostal space on affected side, should hear a whoosh of air if under tension.
7. Immediately follow up needle decompression with thoracostomy (chest tube).

BRONCHOSPASM

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

SIGNS

1. Increased peak airway pressures.
2. Wheezing on lung exam.
3. Increased expiratory time.
4. Increased ETCO₂ with upsloping ETCO₂ waveform.
5. Decreased tidal volumes if pressure control.



INFORM SURGEON



CALL FOR HELP

Bronchospastic patients that develop sudden hypotension may be airtrapping - disconnect patient from circuit to allow for complete exhalation.

TREATMENT

1. Increase FiO₂ to 100%.
2. Deepen volatile anesthetic (sevoflurane = most bronchodilating).
3. Rule out mainstem intubation.
4. Suction ET tube.
5. Administer beta one agonist (albuterol).
6. Change I:E time to allow for adequate exhalation.
7. If severe consider epinephrine (start with 10 mcg IV and escalate, monitor for tachycardia and hypertension).
8. Consider ketamine: 0.2 - 1.0 mg/kg IV.
9. Rule out anaphylaxis (hypotension/tachycardia/rash) - if anaphylaxis, switch to anaphylaxis cognitive aid.
10. If severe or persistent, may require post operative ventilation.

DELAYED EMERGENCE

By T. Kyle Harrison, MD • Larry F. Chu, MD, MS • Sara Goldhaber-Fiebert, MD

CHECK

Confirm that all anesthetic agents (inhalation/ IV) are **OFF**.
Check for residual muscular paralysis with **Train of Four** if patient is asleep, and reverse accordingly.

CONSIDER

Consider:

1. Narcotic reversal: start with 40 mcg IV naloxone; repeat every 2 minutes up to 0.2 mg.
2. Benzodiazepine reversal: start with 0.2 mg flumazenil every 1 minute; max dose = 1 mg.
3. Reversal of scopolamine specifically, or many agents generally: 1 mg IV of physostigmine (watch for cholinergic crisis: bradycardia, bronchospasm, seizures, incontinence).

CHECK

Check:

1. Rule out hypoxemia (pulse ox).
2. Blood glucose level and **treat hypo- or hyperglycemia**.
3. Arterial blood gas plus electrolytes.
Rule out: CO₂ narcosis from hypercarbia.
Rule out: hypo- or hypernatremia.
4. Neuroexam if concerning, **obtain stat head CT scan** and consult neurology/ neurosurgery to rule out possible cerebral vascular accident.
5. Patient temperature and **warm patient** if <34 degrees Celsius.

TREATMENT

1. Correct any abnormalities in oxygenation, ventilation, laboratory values, or temperature.
2. **Perform complete neurological exam** if possible (pupils, asymmetric movement, gagging/ coughing, or focal neurological deficit).
3. If residual sedation persists, monitor the patient in the ICU with **neurological follow up**; repeat head CT scan in 6-8 hours.

OXYGEN FAILURE

O₂ CROSS OVER/ PIPELINE FAILURE

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS • Steven K. Howard, MD •
Seshadri C. Mudumbai, MD • T. Kyle Harrison, MD

IMMEDIATE LIVESAVING ACTIONS

1. **Disconnect the patient from the machine and ventilate with an Ambu™ bag on room air.**

Do **not** connect the patient to auxiliary flowmeter on machine – comes from SAME central source!

2. Obtain full E cylinder of oxygen with a regulator, **OR** disconnect pipeline oxygen and open O₂ tank on back of anesthesia machine (check that it is not empty).

3. Connect Ambu™ bag or Jackson Rees circuit to oxygen tank and **ventilate**.

4. Connect adaptor to allow monitoring of respiratory gases:

Is the patient receiving 100% oxygen?

5. Call for help & diagnose machine problem.
6. Maintain anesthesia (if necessary) with IV drugs.

POWER FAILURE

By Sara Goldhaber-Fiebert, MD • Larry F. Chu, MD, MS • T. Kyle Harrison, MD

IMMEDIATE LIFESAVING ACTIONS

1. **Get additional light sources:**
 - Laryngoscopes, cell phones, flashlights, etc.
2. **Open doors and shades** to let in ambient light.
3. **Confirm ventilator is working and if not, ventilate patient with Ambu bag and switch to TIVA.**
4. If monitors fail, **check pulse and manual blood pressure.**
5. **Request Transport Monitor** or defibrillator monitor.
6. **Confirm adequate backup O₂ supply.**
 - Power failure may affect oxygen supply or alarms.
7. **Check extent of power failure.**
 - Call bio-med or engineering.
 - Is the problem in one OR, all ORs, or hospital-wide?
 - If only in your OR, check if circuit breaker has been tripped.