Transverse Abdominis Plane (TAP) Block Bootcamp

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Course Overview

The TAP block bootcamp is designed to teach learners how to safely perform a Transversus Abdominis Plane (TAP) block.

- Learners will recognize the typical sonographical images of the lateral abdominal wall muscles, pertinent to perform the block.
- Learners will appreciate the differences between ultrasound guided “in-plane” and “out-of-plane” needle approaches. Furthermore, they will have the opportunity to train these various approaches on a simulated model.
- Learners will be able to evaluate the risk of local anesthetic systemic toxicity (LAST) when performing a TAP block in a patient with altered local anesthetic (LA) clearance, such as in the case of acute fatty liver of pregnancy (AFLP).

At the end of the bootcamp, learners should be able to safely perform a TAP block and understand the pertinent pharmacological considerations to avoid LAST.

Educational Rationale:
TAP blocks are increasingly popular to manage post-operative pain. Because the target structure of the block is the neuro-fascial plane between the Internal Oblique Muscle (IOM) and the Transverse Abdominis Muscle (TAM) rather than a single neural structure, this block is ideal to introduce novices to ultrasound guided regional anesthesia.

Problem Based Learning - Case Review (Optional)
Anesthesiologists should be aware of applied local anesthetic pharmacokinetics, above and beyond the "mg/kg pattern"; taking into consideration patient specific considerations, such as impaired local anesthetic clearance, essentially lowering the threshold for LAST.

The attached Problem Based Learning case review illuminates this kind of scientific thinking and compares regional anesthesia to alternative analgesic methods. It also highlights the topic of anticoagulation and its impact on regional anesthesia. The case report of a parturient is described, as the TAP block is commonly used in the post-partum population.

Duration of Training Session: 1.5 hours

Frequency of Course: Once per trainee

Number of Trainees per Session: 4-6 learners

Curriculum has been internally peer-reviewed within the University of Washington’s Department of Anesthesiology and Pain Medicine prior to submission within AAMC’s MedEdPORTAL.
3. Target Trainees

**Primary:** Anesthesia residents in their obstetric anesthesia rotation

**Secondary:** Anesthesia attending physicians, CRNAs, anesthesia residents
4. Prerequisite Knowledge and Skills

**Required background knowledge:**

- Basic knowledge of abdominal wall anatomy.
- Basic knowledge of ultrasound guided regional anesthesiology principles
- Basic pharmacology knowledge pertaining to local anesthetic clearance

**Required background skills expected in trainees prior to receiving training in the target course:**

- None required
5. Goals and Objectives

ACGME Competencies: Medical Knowledge\(^A\), Patient Care\(^B\), Interpersonal and Communication Skills\(^C\), Professionalism\(^D\), Systems-based Practice\(^E\)

Goal 1: Learning how to perform a TAP block

**Objective 1a – Anatomical Identification**
Upon completion of this learning activity, participants will be able to use ultrasound to recognize the relevant anatomical structures to safely perform a TAP block.\([A,B]\)

**Objective 1b – Implications**
Learners will be expected to recognize and describe the implications of Acute Fatty Liver of Pregnancy (AFLP) on Cesarean delivery and post-Cesarean delivery analgesia.\([A,B]\)

**Objective 1c – TAP Block**
Using a simulated tissue, learners will be able to demonstrate the skill of placing a TAP block.\([A,B,E]\)

Goal 2: Indications and Contraindications

**Objective 2a – Indications**
Upon completion of this learning activity, learners should be able to list the indications for peripartum transversus abdominis plane (TAP) blocks under consideration of the typical peripartum pharmacology.\([A,B]\)

**Objective 2b - Contraindications**
Upon completion of this learning activity, learners should be able to identify and list contraindications for transversus abdominis plane (TAP) blocks after Cesarean sections under consideration of peripartum pharmacology.\([A,B]\)

Goal 3: Pharmacokinetics

**Objective 3a - Pharmacokinetics**
Upon completion of this learning activity, participants should be able to describe normal and pathological peripartum local anesthetics pharmacokinetics using the example of AFLP. Furthermore participants should be able to diagnose and treat local anesthetic systemic toxicity (LAST).\([A,B]\)
6. Instructor Notes

General Information
- This course is designed to:
  o Train the technical skills associated with ultrasound guided needle placement.
  o Teach abdominal wall anatomy (muscles, nerves, vessels, peritoneum, colon).
  o Teach how to perform safely a bilateral ultrasound guided TAP block.
- Additional information will be taught pertaining to:
  o Procedural checklist
  o Anatomical/procedural “pearls”
  o Expected timing and management of LA toxicities, using the ASRA guidelines
  o Factors associated with impaired LA clearance using the case of AFLP

Pre-Simulation Introduction
- Didactic PowerPoint presentation (see Appendix A)

Problem-Based Learning
- Optional Problem Based Learning Case Review Exercise (see Appendix C)

Environmental Set-Up
- See Section 10
7. Common Errors and Prevention Strategies

Common Errors and Prevention Strategies:

a. Poor anatomical understanding and inability to recognize ultrasound landmarks
   **Strategy:** Learners will be provided a handout explaining the anatomical landmarks and will work with the instructor to recognize landmarks with ultrasound in a structured manner.

b. Poor understanding of TAP indications, choice of local anesthetic (LA) and expected block duration
   **Strategy:** During the workshop, indications will be discussed in detail. Additionally, LA pertaining information is included in the Problem Based Learning Case Review (See Appendix C).

c. Poor awareness of LA toxicity signs and their respective management
   **Strategy:** Signs of LA toxicity will be discussed during the workshop and AFLP case report. If learners continue to struggle, signs and management protocol can be reviewed with the instructor.
Key methods for delivering cognitive training include the following:

- Pre-course Review of the Didactic Lecture Materials (See Appendix A)
- Pre-Simulation Problem Based Learning Exercise (Optional) (See Appendix C)
- Simulation Workshop (See Skills Training Section 9)
9. Skills Training

Skills Training will include practice and assessment of performance for the following:

- **Location of anatomical landmarks with ultrasound** (See Appendix D).
  
  *Description:* Using volunteer models, learners will practice a systematic ultrasound guided approach. Specific anatomical landmarks such as the anterior superior iliac spine (ASIS), peritoneum, arteries, muscles, ilioinguinal (IIN) and iliohypogastric (IHG) nerves will be highlighted.

- **Use of simulated tissue for in-plane needle placement of a TAP block** (See Appendix D).
  
  *Description:* Learners will be provided with a tissue model and will be expected to demonstrate an in-plane needle placement simulating a TAP block. Learners will be expected to perform in- and out-of-plane needle placements in a model to understand the pro and cons of these two commonly used approaches.

**Information for Instructor**

**Learners should be able to perform the following steps in a simulated environment:**

- Systematic scanning of abdomen, beginning at the umbilicus:
  - Slowly moving laterally with linear ultrasound (US) probe, pointing out: first the rectus muscle, then the rectus sheet, and then traveling more lateral: pointing out the three muscles of the lateral abdominal wall: namely the External (EOM) and Internal Oblique Muscle (IOM) and the Transverse Abdominis Muscle (TAM). Medial of the TAM the peritoneum should be depicted. Subcutaneous and fatty tissue should be pointed out, especially the fact that they don’t have a border, opposed to the muscles.
  - The learner will instruct the volunteer model to contract the abdominal muscle, so the learners can clearly distinguish the muscle from the subcutaneous tissue.
  - Once a mid-axillary position is reached, the probe should be gently tilted until the facias between the EOM, IOM and TAM become clearer. The layer between the IOM and the TAM is the TAP plane target area of the block and should be depicted very clearly and sharp.
  - Once a suitable image is obtained, the learner will capture and save the image. The probe should then be moved back to the medial end of the 3 muscles and moved cephalad, towards the ribs. The change in the anatomical orientation and size of the muscles should be noted.
  - The upper epigastric artery should be depicted, using the color mode of the US machine. Then the deep circumflex artery, on the lower end of the abdomen should be identified and depicted.
9. Skills Training

- The US probe should then be placed on the ASIS and directed toward the Umbilicus. A careful and slow scanning technique including occasional gentle tilting of the probe should help to clearly visualize the IIN and the IHN in the TAP plane.

Additional Notes:
- This exercise should not take longer than 5-8 minutes.
- Not every volunteer model has a favorable anatomy. If the anatomy is poor, the volunteer model should be changed.

Use of gel model for needle placement:
- While the students scan the volunteer model, one student should practice ultrasound guided in-plane and out-of-plane approaches on the gel model, ideally using a second ultrasound machine.
- The student should try to target 3 targets in the gel model, each being at a different depth while practicing different approach techniques. Clinical examples should be given by the instructor for which commonly used blocks which technique is preferable.
- When the needle is in full sight, the student should increase the gain, to experience the reverberation effects, caused by the increase in ultrasound energy.
- If the machine has needle recognition software, the student should be instructed to complete 3 approaches with and 3 without the recognition software, to experience the difference.
10. Equipment Set-up

Simulation Environment preparation

Setting: Virtual Operating Room:

___ Model (volunteer)
___ Ultrasound machine, ideally two machines equipped with enhancing software
___ Linear Ultrasound Probe
___ Ultrasound Gel
___ Personal Protective Equipment (Mask, Gloves, etc.)
___ Ultrasound gel model with possibly “implanted targets”
___ 17G Touhy needles
11. Assessment Methods

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Appendix A: Pre-Session Didactic

TAP BLOCK
Why it works

The transverse abdominis plane (TAP) block affects the sensory nerve supply of the anterior-lateral abdominal wall:

- T7-T12 intercostal nerves
- Ilioinguinal nerve
- Iliohypogastric nerve
- Lateral cutaneous branches of the dorsal rami of L1-L3

EOM: External Oblique Muscle
IOM: Internal Oblique Muscle
TAM: Transverse Oblique Muscle

TAP BLOCK

Caudal

Cephalad

PLACEMENT OF TAP BLOCK
Ultrasound probe position for TAP Block: Midaxillary line, height of the umbilicus

- EOM: External oblique muscle
- IOM: Internal oblique muscle
- TAM: Transverse abdominis muscle
Appendix A: Pre-Session Didactic

Clinical Pearl:
Lentoid spread of the injectate

Clinical Pearl
Echogenic needle used

WFSA Tutorial 239, 2011
Appendix A: Pre-Session Didactic

The Medial abdominal wall:

![Diagram of the Medial abdominal wall showing external oblique, internal oblique, transversus abdominis muscle, and rectus muscle.]

The lateral abdominal wall:

![Diagram of the Lateral abdominal wall showing EOM, HOM, TAM, and arrows pointing to structures.]

Transverse Abdominis Plane Block
Appendix A: Pre-Session Didactic

TAP BLOCK
Where not to inject!

1. Deep circumflex artery
2. Superior epigastric artery
3. Inferior epigastric artery

Case reports of toxicity after TAP block exist.

CASE REPORT
Transverse abdominis plane catheters for post-caesarean delivery anaesthesia: a series of five cases
L. Bollag, P. Richebe, C. Ortner, R. Landau
Department of Anesthesiology and Pain Medicine, University of Washington, Seattle, USA

1. 
2. 
3. 
4. 

EOM: External Oblique Muscle
IOM: Internal Oblique Muscle
TAM: Transverse Abdominis Muscle

Catheter with air bubble

Needle
Appendix A: Pre-Session Didactic

TAP catheters have been used for:

- Inguinal hernia surgeries
- Laparatomies (adult and pediatric)
- War injuries
- Gynecological surgeries

1 RCT compared thoracic epidural with tap catheters for laparotomies and found equal analgesia between the two modalities if tramadol was added to the TAP group to compensate for the absent visceral analgesia.

Comparison of analgesic efficacy of subcostal transversus abdominis plane blocks with epidural analgesia following upper abdominal surgery.
Niraj Anaesthesia 2011

The price to pay for good analgesia...... Epidural or TAP Catheter?

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<th>EPIDURAL “issues”</th>
<th>TAP Catheter “issues”</th>
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<tr>
<td>Hypotension</td>
<td>Absent visceral analgesia</td>
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<tr>
<td>Urinary retention</td>
<td>Little data available concerning the timing and application modus (bolus or continuous drip)</td>
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<td>Motor block</td>
<td>Field block requiring large volumes (caveat LAST)</td>
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<td>Requires hospital environment</td>
<td>Technically challenging in the obese</td>
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Transverse Abdominis Plane Block
Appendix A: Pre-Session Didactic

Indications for TAP blocks (RCT’s):

- Laparoscopic Appendectomies: 1
- Appendectomies: 2
- Laparotomies: 5
- Laparoscopic Cholecystectomy: 2
- Inguinal Hernia: 2
- Cesarean Sections: 9

Abdallah RAPM 2012

TAP block for Cesarean Section analgesia

9 RCT’s: McDonnell 2008

1. TAP Block useful
   -> if no intrathecal morphine could be given
2. Intrathecal morphine produces superior analgesia
3. But causes more side effects (like pruritus and nausea)
   ➔ The TAP block is an accepted alternative
to intrathecal morphine

Mishriky Can J Anesth 2012
Appendix A: Pre-Session Didactic

How much, What and When is being injected?
17 RCT’s:
Timing of TAP injection: 50:50 (before and after surgery)
Injectate volume: mg/Kg based or fixed volumes (15-20ml)

Abdallah RAPM 2012

Figure 1: Sequence of the transversus abdominis plane (TAP) catheter placement

Legend:
1.1: Visualization of the transversus abdominis plane (TAP)
1.2: Hydro-dissection of the plane with local anesthetic solution
1.3: Advancement of the catheter 3-4cm in the plane and final placement control by xero-dissection
1.4: Catheter fixation at the skin by transparent dressing (Tegaderm)
EOM: External oblique muscle
IOM: Internal oblique muscle
TAM: Transversus abdominis muscle
Needle: 18G Tuohy needle
Learner Name: ___________________________________ Date: ____________________

INSTRUCTIONS:
MATCH THE PROBE POSITION TO THE ULTRASOUND IMAGE.

Answer Options: A, B, C, D, or Not Pictured
Appendix B: Pre-/Post-Test

_____ Probe Position

_____ Probe Position
Appendix B: Pre-/Post-Test

_______ Probe Position

_______ Probe Position
Appendix B: Pre-/Post-Test

_______ Probe Position

_______ Probe Position
Appendix C: Problem Based Learning

**Problem Based Learning:**

**Exercise 1:**
Prior to the simulated skills training, the instructor will present learners with the following case:

A 25-year old G2P0 woman at 37 0/7 weeks of gestational age presented in preterm labor with cervical dilatation of 4 cm. Her signs and symptoms included a history of three weeks of nausea/vomiting, somnolence, mild hypertension (140/85 mmHg), and clinical jaundice. Although she is able to comprehended questions and seems oriented to situation, time and place, she is somewhat lethargic. Initial laboratory tests showed WBC 20k/µL, Hct 41%, platelets 141 k/µL, INR 1.9, fibrinogen 95 mg/dL, a 2+ proteinuria, elevated creatinine 2.1mg/dL, hypoglycemia 68 mg/dL, direct bilirubinemia 9.0 mg/dL, AST /ALT 59/63 U/L, alkaline phosphatase 1000 IU/L, ammonia 101 mg/dL. 

**Question 1:** What is your differential diagnosis for this clinical picture?

The obstetric team decides to proceed by cesarean delivery due to late decelerations on fetal heart monitoring and the mother’s altered mental status. The patient continues to be somewhat lethargic, her BMI is 23, and she has no signs suggestive of difficult laryngoscopy. The alteration in mental status is not felt to be sufficiently severe enough to impair the patient's capacity for informed consent for the cesarean section. Along with the surgical consent, the anesthesia team obtains consent for general anesthesia and a post-operative TAP block to be done, as needed, based on clinical assessment at emergence.

**Question 2:** What do the American Society of Regional Anesthesia (ASRA) guidelines for neuraxial anesthesia and anticoagulation indicate regarding the performance of spinal or epidural anesthesia for this patient?

**Question 3:** Develop an anesthetic plan for managing this patient. Specifically address coagulation status, including your rationale for correcting (or not correcting) the coagulopathy.

**Question 4:** Discuss other tests of coagulation and their application in intraoperative and postoperative management of this patient. Provide an evidence-based approach in your discussion.

General anesthesia is started per rapid sequence induction using fentanyl, propofol and succinycholine followed by an uneventful intubation. After the cesarean delivery of a 2800 gram healthy male, with an APGAR (5 min) of 8, the patient can be extubated and is taken to the post anesthesia care unit for further observation.

Due to her fluctuating mental status, opioids for postoperative analgesia are withheld. 

**Question 5:** What is currently considered the gold standard for post cesarean delivery pain management? Compare and contrast TAP block with opiates and other methods of pain relief.

The patient continues to follow commands and is able to communicate, but remains intermittently lethargic, similar to her pre-delivery status, and her ability to administer herself opioids by IV PCA remains questionable. It is therefore decided to provide post-cesarean analgesia with a TAP block.

**Question 6:** Summarize the TAP block. Include a discussion of relevant anatomy, targeted nerves, performance of the block, local anesthetic concentration and volume, and indications.
Appendix C: Problem Based Learning

Post-delivery, the INR is 2.1 and fresh frozen plasma (FFP) is administered prior to the ultrasound guided TAP block. Using the in-plane technique, 20 ml of bupivacaine 0.375% are injected bilaterally using a 5cm needle (B-Braun Medical USA, Bethlehem, PA, USA).

Question 7: How long do you predict your TAP block will last, taking into consideration drug(s) chosen for the block?

The analgesic effect of the block reduces VAS pain scores from 9/10 down to 3/10 within 20 minutes of the procedure. The pain scores remain below 5/10 for the next 12 hours. After the block placement, the patient is transferred to the ICU for closer post-operative monitoring and regular neurological checks.

Question 8: When would you expect plasma local anesthetic concentrations to peak after a TAP block?

Twelve hours later, the patient complains of increasing pain at the site of her abdominal incision. Fifteen hours after the first TAP block, a second ultrasound guided TAP block is performed. While monitoring for inadvertent intravascular injection, the same amount of local anesthetic is bilaterally injected again. Minutes after the block, VAS score begin to decrease from 10/10 to 6/10.

Question 9: Critically evaluate management up to this point, with emphasis on reinjection interval. Include in your discussion half-life of bupivacaine and any factors that could affect metabolism and excretion.

Question 10: Which alternative drug administration techniques exist? Can you provide an evidence based approach in your discussion?

Unfortunately, thirty minutes after the injection a grand mal seizure is observed.

Question 11: How does pregnancy affect susceptibility to local anesthetic toxicity?

Question 12: What is the theory behind intra-lipid’s use as a rescue agent?

Question 13: Investigate the most up-to-date published guidelines for management of LAST. Discuss components of guidelines and checklists, with emphasis on use of lipid infusion including ideal timing.

Question 14: Was this patient’s LAST risk increased, and if so, why?

Problem based learning discussion points

Question 1: What is your differential diagnosis for this clinical picture?

- While pre-eclampsia with HELLP syndrome should be considered, this is not by any means a typical presentation. An infectious or inflammatory hepatitis with subsequent liver failure could also present in this manner. This patient has acute fatty liver of pregnancy (AFLP) which has an incidence of 1 per 13 000 deliveries (1). The onset of AFLP is between the 30th and 38th week of gestation, and is characterized by micro vesicular steatosis of the liver (2).
- Clinical symptoms overlap with other pregnancy-related morbid conditions: Patients with AFLP experience nausea and vomiting (approximately 75%), epigastric pain (50%), anorexia, jaundice, and encephalopathy (3) presenting similar symptoms like HELLP and pre-eclampsia, but have a
Appendix C: Problem Based Learning

different pathophysiology (2). Aminotransferases are elevated with some patients having levels above 1000 IU/L.

- **Extra-hepatic manifestations** include acute renal failure with hyperuremia, thrombocytopenia, and coagulopathy. Hypoglycemia may occur with AFLP due to the severity of hepatic dysfunction. Radiological and histological examinations have not been prospectively studied, and in some situations may pose a significant risk for bleeding. The diagnosis is made clinically in the absence of a specific marker or test.

- Within days of the delivery, laboratory values improve. However, after the delivery (hours to days) the mother may continue to experience severe hepatic dysfunction requiring intensive care monitoring, intubation, TPN, dialysis, and on occasion, liver transplantation. Recent literature discusses the treatment of acute liver failure, including AFLP, by a Molecular Adsorbent Recirculating System (MARS) (4). It is a membrane-based blood purification system, analogous to dialysis for patients in renal failure - using an albumin-based dialysate. MARS therapy was suggested in this patient after her seizure, but she had already begun to improve clinically.

- **AFLP is an inherited disorder** possibly affecting future pregnancies as well as the offspring and their subsequent pregnancies. Patients can be genetically tested for a mutation in the gene encoding for LCHAD, the HADHA gene. However, identifying the mutation does not imply the patient will necessarily develop the disease - likely multiple genes are involved. In one cohort of 12 mothers that were homozygous for G1528C, 79% developed AFLP, HELLP, or both (3).

**Question 2:** What do the American Society of Regional Anesthesia (ASRA) guidelines for neuraxial anesthesia and anticoagulation indicate regarding the performance of spinal or epidural anesthesia for this patient?

- The short answer to this question is that the ASRA guidelines do not explicitly address this situation. The ASRA guidelines explicitly describe how an INR of less than 1.5 found during monitoring of warfarin usage impacts the bleeding risk at the time of removal of an epidural catheter. The ASRA task force focused on this issue of INR and epidural removal because historically this is one of the most common clinical pathways for lower extremity total joint arthroplasty, involving the initiation of warfarin therapy with an epidural catheter in-situ making the timing of removal of epidural catheters an important safety concern. This clinical pathway is still part of clinical practice for some institutions, but recent evidence seems to suggest that this INR “cut-off” might be too conservative (5). The references cited in the ASRA guidelines suggest that with an INR of <1.5 there is still at least 40% of factor VII activity (6) making significant bleeding upon epidural catheter removal very unlikely. This “cut-off” of 1.5 has been adopted by some providers into a general guideline for neuraxial needle placement and epidural catheter removal under other circumstances, but it should be noted that the value of the INR in predicting the risk of hemorrhagic complications prior to invasive procedures is notoriously poor (7). The guidelines mention that in a case series report on neuraxial hematomas by Moen et al. (8) eleven of the patients in the series had some form of coagulopathy and two of those patients were parturients. The INR changes associated with the failure of protein synthesis in AFLP are not easily translated into a quantifiable risk of bleeding. An INR of 1.5 probably does not indicate the same degree of coagulopathy in the clinical context that the ASRA guidelines addressed (the initiation of warfarin therapy) as it would with a different source of coagulopathy such as liver failure with AFLP.
Question 3: Develop an anesthetic plan for managing this patient. Specifically address coagulation status, including your rationale for correcting (or not correcting) the coagulopathy.

- Consent: In the event that the patient did not appear to have capacity for consent due to altered mental status then consent would be obtained for the general anesthetic and post-operative tap block from an appropriate surrogate decision maker. As the TAP block is not a plexus block where patient feedback might be considered to enhance safety, then consideration could be given to performance of the block while under general anesthesia particularly if patient cooperation might be a problem.
- The patient’s coagulopathic status obviously plays a major role in the determination of your anesthetic plan. As noted in the discussion in question 2, there seems to be a de facto “standard” of avoiding neuraxial anesthesia and analgesia in patients with an INR greater than 1.4. There is good evidence that transfusions of fresh-frozen plasma are relatively ineffective, particularly at low volumes e.g. 2 units, in achieving improvement of the INR to the magical target of 1.4. INR, as tested in untransfused FFP is frequently greater than 1.4, by extension, the closer the INR is to 1.4 the greater the number of transfusions required to achieve further incremental improvement unless the patient is able to produce and contribute some of their own factors (9). It will likely require a prolonged delay and multiple transfusions to have any chance of achieving a specific goal of a low, almost normalized INR.
- The two considerations for the treatment of this coagulopathy are: could you create a clinical scenario where neuraxial anesthesia would be safe and do you need to correct the coagulopathy simply to avoid massive intraoperative and post-partum blood loss regardless of anesthetic choice? Given the patient safety and medico-legal consequences of an epidural hematoma in this patient, there may not be very many anesthesiologists who would attempt spinal or epidural anesthesia, but there should be room for a rational and nuanced discussion of the anesthetic risks and benefits as they apply to this particular patient.
- A recent large survey by Bateman et al examining the occurrence of neuraxial hematomas from 11 academic medical centers in the US includes reports of two hematomas in patients whose INRs were 1.6 at the time of needle placement. Of course, the denominator data of how many patients with elevated INRs had epidurals placed without incident is missing but these sorts of incidents are concerning and may, in a very indirect manner, support the de facto “standard” of 1.5 (10). Reassuringly, in this survey, there were no hematomas reported among the almost 80,000 parturients.
- After discussion with the obstetric team, regarding the risk of further delay for transfusion versus the risk of taking the patient to the OR immediately, the decision should be reached with an understanding that normalization of the INR goal is very unlikely to be achievable. The relatively low fibrinogen should trigger consideration for the transfusion of cryoprecipitate or treatment with lyophilized fibrinogen concentrate in countries where it is available. Given the rare occurrence of any hemorrhagic complication, it is extremely unlikely that there will ever be a study providing any level of direct evidence on the predictive value of the newer whole blood coagulation tests and risk of rare hemorrhagic complications such as neuraxial hematoma.

Question 4: Discuss other tests of coagulation and their application in intraoperative and postoperative management of this patient. Provide an evidence-based approach in your discussion.
Appendix C: Problem Based Learning

- There has been a study evaluating the correlation between thromboelastogram (TEG) results and platelet number in parturients which suggests some value of these tests in comparison to other tests of platelet function but this was not performed in patients at risk for coagulopathy, nor were the results correlated with a clinically significant outcome(11).
- Another study attempted to define TEG reference ranges for healthy parturients and evaluated the impact of LMWH on the TEG, but again did not correlate clinical outcomes and TEG results (12). If you did feel strongly that a neuraxial anesthetic was best for the patient, a normal or near normal TEG may be reassuring that the patient is not at high risk for the potentially devastating complication of neuraxial hematoma.

**Question 5: What currently is considered the gold standard for post cesarean delivery pain management? Compare and contrast TAP block with opiates and other methods of pain relief.**

- Randomized clinical trials to assess the efficacy of a single ultrasound-guided bilateral TAP block for post-cesarean delivery analgesia have demonstrated limited benefit when compared, or added to, intrathecal morphine, considered the standard for postoperative pain control (14-17). Possible explanations for the lack of additional benefits of a single injection TAP block in women already receiving intrathecal morphine may be the relatively limited duration of action of a single injection TAP block.

**Question 6: Summarize the TAP block. Include discussion of relevant anatomy, targeted nerves, performance of the block, local anesthetic concentration and volume, and indications.**

- The ultrasound-guided transversus abdominis plane (TAP) block may be offered for post-Cesarean analgesia, particularly when standard regimens with intrathecal opioid or non-steroidal anti-inflammatory drugs are contraindicated or insufficient. Local anesthetic solutions, injected into the plane between the internal oblique muscle (IOM) and the transverse abdominis muscle (TAM) can block the T7–12 intercostal, the ilioinguinal, and the iliohypogastric nerves, as well as the lateral cutaneous branches of the dorsal rami of L1–3 reducing the somatic nociceptive input from the wound to the abdominal wall (13).
- Abdominal wall blocks, however, do not affect the uterine, visceral component of post-cesarean delivery pain.

**Question 7: How long do you predict your TAP block will last, taking into consideration drug(s) chosen for the block?**

- In our experience these blocks last only about 12-16 h depending on amount, type of local anesthetic and adjuvant used. Alternatively, the superiority of intrathecal morphine for the visceral component of post-cesarean delivery pain may mask any potential effect of a single shot TAP block if given at the same time.

**Question 8: When would you expect plasma local anesthetic concentrations to peak after a TAP block?**

- Other local anesthetics have been studied with regards to TAP block pharmacokinetics in the non-pregnant populations. Kato et al at determined when peak plasma levels were observed in patients given a total of 400mg of lidocaine via bilateral TAP blocks; peak levels occurred at 15
minutes (18). Griffiths et al performed a study in which plasma levels of ropivacaine were measured at 15 minutes intervals in the first hour, noting peak levels at 30 minutes (19). Although no formal studies have been assessed with bupivacaine, the onset of LAST in our patient falls within the range of onset of other amide local anesthetics.

- Ropivacaine might have an increased safety profile regarding cardio-toxicity (20), yet case reports of cardiac toxicity with ropivacaine do exist (21). In this case report, no EKG changes were observed besides the tachycardia during the seizure.

**Question 9:** Critically evaluate management up to this point, with emphasis on reinjection interval. Include in your discussion half-life of bupivacaine and any factors that could affect metabolism and excretion.

- The time interval between the blocks was 15 hours. For patients with normal hepatic and renal function, this would be ample time: the estimated terminal half-life of bupivacaine is 2.7 hours +/- 2 hours per AstraZeneca, the pharmaceutical company manufacturing bupivacaine in the United States. In a pharmacokinetic study using bupivacaine for axillary blocks, the terminal half-life for bupivacaine was found to be 11.5 hours (22).

- Given that we would usually wait five half-lives for elimination of the drug, and given this patient’s condition, 15 hours was not a reasonable amount of time to expect >96% metabolism and excretion.

- In this patient with severely compromised hepatic function, the safe interval between injections to avoid toxicity is essentially unknown.

**Question 10:** Which alternative drug administration technique exists? Can you provide an evidence based approach in your discussion?

- Further studies involving the pharmacokinetics of sequential TAP blocks in the parturient would help elucidate the appropriate interval; furthermore, the pharmacokinetics of TAP block continuous infusions would be useful as these blocks become more widely used. There have been several case reports on the use of TAP catheters in the non-obstetric population. These reports include analgesia after inguinal hernia repair, laparotomy in pediatric cases, combat injuries and gynecological procedures (23-26). One randomized clinical trial comparing subcostal TAP catheters with epidural analgesia following upper abdominal surgery found that postoperative analgesia was equivalent if visceral analgesia, which was lacking in the TAP group, was compensated for with tramadol (27). One case report series using TAP catheters to manage post cesarean pain exists (28).

- Besides the obvious benefits of improved analgesia provided by TAP catheters, other theoretical advantages include reduced opioid-related side effects and increased mobility allowing for earlier ambulation, the ability to visit infants admitted to remote intensive care units, spontaneous voiding along with greater independence which may increase maternal satisfaction. These advantages may be particularly relevant in women with challenging medical conditions.

**Question 11:** How does pregnancy affect local anesthetics susceptibility?

- Hormonal and biochemical changes of pregnancy may increase LA susceptibility, clinically translated as a 30% decreased LA requirement. Pregnancy results in a progressively decreased
Appendix C: Problem Based Learning

AAG (alpha 1 glycoprotein) concentration, resulting in more unbound and therefore active lidocaine and bupivacaine (29).

**Question 12: What is the theory behind intra-lipid function?**
- Bupivacaine has been shown to be especially potent in inhibiting mitochondrial fatty acid transport. Under normal aerobic conditions, fatty acids are the preferred fuel of the heart responsible for 80–90% of cardiac adenosine triphosphate (ATP) synthesis (30). If fatty acid transport is suddenly interrupted, the rapid loss of ATP production contributes to cardiac toxicity.
- **Intralipid or lipid rescue**, is a lipid emulsion therapy, thought to (amongst other intracellular effects) reverse the aforementioned inhibition of mitochondrial fatty acid transport (31). It has become increasingly popular to treat cardio toxicity caused by LAST (32).

**Question 13: Investigate the most up-to-date published guidelines for management of LAST. Discuss components of guidelines and checklists, with emphasis on use of lipid infusion including ideal timing.**
- In regards to the timing of lipid infusion in LAST, the revised ASRA checklist 2012 remains non-specific. Find here the referring passage: “Timing of lipid infusion in LAST is controversial. The most conservative approach, waiting until after ACLS has proven unsuccessful, is unreasonable because early treatment can prevent cardiovascular collapse. Infusing lipid at the earliest sign of LAST can result in unnecessary treatment since only a fraction of patients will progress to severe toxicity. The most reasonable approach is to implement lipid therapy on the basis of clinical severity and rate of progression of LAST.” (33).
- The TAP block has been recently described as a safe and useful post-cesarean analgesic modality. In this patient however, the threshold for local anesthetic toxicity was likely reduced and while providing a second TAP block to provide analgesia seemed appropriate, this resulted in LAST.

**Question 14: Was this patient’s LAST risk increased, and if so, why?**
- The differential diagnosis for the seizure includes eclampsia, posterior reversible encephalopathy syndrome (PRES), hypomagnesaemia, hypoglycemia, hepatic encephalopathy, and intracranial bleeding. Due to the temporal relationship of events, with the seizure occurring within 30 minutes of a second TAP block, local anesthetic systemic toxicity (LAST) was considered the most likely etiology for the patient’s seizure.
- Tsen et al., suggested that parturients, in general, may be at higher risk for LAST because of an increased free fraction of plasma bupivacaine (29,34). In AFLP, third trimester insidious liver dysfunction leads to a decreased production of serum proteins that bind to local anesthetics such as bupivacaine. Bupivacaine, in particular, is approximately 95% protein-bound. Therefore, in patients with decreased serum albumin and alpha-1-glycoprotein, the free-fraction of bupivacaine is augmented making an individual more susceptible to LAST (29).
- Providing good post cesarean section analgesia in parturients with AFLP remains a challenge: decreased liver and renal function, encephalopathy, coagulopathy and increased local anesthetic toxicity are all complicating factors.
Appendix D: Performance Checklist

Learner Name: __________________________________ Date: __________________________

TAP PERFORMANCE CHECKLIST

Placement and Set-Up
__ Proper positioning of model
__ Ensures environment/supplies are available and within reach
   __ Placement of towels
   __ Placement of US machine

Ultrasound Machine
__ Proper start-up of ultrasound machine
   __ Setting: Nerve mode
   __ Probe starting depth: 4-6 cm

Operation of Ultrasound Machine
__ Proper adjustment of gain and depth
__ Systematic scanning of abdomen, beginning at the umbilicus
   __ Lateral movement with US probe pointing out the following
      __ Rectus muscle
      __ Rectus sheet
      __ EOM
      __ IOM
      __ TAM
      __ Peritoneum
      __ Subcutaneous and fatty tissue
      __ IIN
      __ IHN
__ Photo Capture
   __ Target area for block

Acquisition of needle guiding skills using a Gel Model
   __ Visualization of reverberation
   __ 3 in-plane and out-of-plane approaches with needle
# Appendix E: Session Evaluation

## Simulation Session Evaluation TAP

**Facilitator:** __________________________  **Date:** _______________

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<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
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<td>1. The simulation case provided is relevant to my work.</td>
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<td>2. The simulation case was realistic.</td>
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<td>3. This simulation case was effective in teaching basic ultrasound skills for TAP.</td>
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<td>4. This simulation case was effective in teaching TAP block placement skills.</td>
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<td>5. The debrief created a safe environment.</td>
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<td>6. The debrief promoted reflection and team discussion.</td>
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<td>2</td>
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Can you list/describe 1 or more ways this simulation session will change how you do your job?

**Comments:**
13. References

15. Kanazi GE, Aouad MT, Abdallah FW, Khatib MI, Adham AM, Harfoush DW, Siddik-Sayyid SM. The analgesic efficacy of subarachnoid morphine in comparison with ultrasound-guided transversus abdominis plane block after caesarean delivery: a randomized controlled trial.
13. References

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