Abstract
Trauma is estimated to complicate approximately one in twelve pregnancies, and is currently a leading non-obstetric cause of maternal death. Pregnant trauma patients requiring non-obstetric surgery pose a number of challenges for anesthesiologists. Here we present the successful perioperative management of a pregnant trauma patient with multiple injuries including occult pneumothorax who underwent T9 to L1 fusion in prone position, and address the pertinent perioperative anesthetic considerations and management.

Keywords
Spine surgery, pneumothorax, neuro anesthesia, pregnant, poly trauma

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Competing interests: No competing interests were disclosed.
Grant information: The author(s) declared that no grants were involved in supporting this work.
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How to cite this article: Vandse R, Cook M and Bergese S. Case Report: Perioperative management of a pregnant poly trauma patient for spine fixation surgery [version 1; peer review: 2 approved with reservations] F1000Research 2015, 4:171 (https://doi.org/10.12688/f1000research.6659.1)

First published: 29 Jun 2015, 4:171 (https://doi.org/10.12688/f1000research.6659.1)
Introduction

Perioperative management of a pregnant patients requiring non-obstetric surgery is always challenging for an anesthesiologist. The literature documenting anesthetic, surgical and obstetric management of pregnant poly trauma victims undergoing spine surgery in prone positioning is limited. We present a case of a pregnant polytrauma victim with multiple injuries who subsequently underwent spine fixation surgery in prone position and discuss pertinent anesthetic issues and management.

Case presentation

This is a case of a previously healthy 32 year old female, who presented while 17 weeks pregnant as a level 2 trauma following a motor vehicle collision. She had sustained multiple injuries including Grade II liver laceration, pelvic fracture, bilateral clavicle fractures, C1 transverse process fracture, T11 vertebral body burst fracture, R rib 1–10 fractures, L 1st and 2nd rib fractures, bilateral small pneumothoraces and right pulmonary contusion. On examination, the patient was moderately built and nourished. She was 66 inches tall and weighed 136 pounds. Her vital signs on admission showed: heart rate of 96 beats/minute, respiratory rate of 14–18 breaths/minute, blood pressure of 108/56 mmHg, and O2 saturation of 98% on 2–3 liters of oxygen through nasal cannula. She remained hemodynamically stable throughout and did not show any signs of respiratory distress, although she did have some trouble with coughing and clearing respiratory secretions. A preoperative chest X-ray demonstrated complete collapse of the left lung (Figure 1). The small pneumothorax which was discovered in a computed tomography (CT) of the chest, however, was not apparent in the chest X-ray. After a multidisciplinary discussion, because of the unstable spine fracture, it was decided to perform a posterior T9-L1 fusion under general anesthesia. Her lab values were otherwise normal except for hemoglobin of 9.5 and hematocrit of 27.4.

General anesthesia was induced with propofol, lidocaine, fentanyl and succinylcholine. Following intubation, bronchoscopy was performed and the airway was suctioned given her preoperative chest X-ray. The radial artery was cannulated for hemodynamic monitoring. She was then carefully positioned prone on an open frame Jackson table. Special care was taken to avoid any pressure on the abdomen and all the other pressure points were checked and padded. Anesthesia was maintained with propofol (50 mcg/kg/min) and remifentanil (0.05–0.12 mcg/kg/min) infusions along with 1.0% sevoflurane in 50% oxygen. Phenylephrine was used to support her blood pressure as needed. She remained hemodynamically stable throughout the procedure. She was ventilated with a small tidal volume (300–350 ml) and her peak pressure was closely monitored, which stayed less than 20 cm of H2O throughout. CT-based image guidance was mostly used by the surgeons to limit the intraoperative fluoroscopy. She received 1300 ml of crystalloids and 500 ml of albumin. She produced 400 ml of urine and lost approximately 200 ml of blood. Total duration of anesthesia was approximately 4 hours. She was successfully extubated at the end of the procedure. She remained stable post operatively. However, she did require 22 days of inpatient care due to multiple injuries she had sustained during the trauma. She was successively discharged home. She later came back at term and delivered a healthy baby by elective Caesarean section under general anesthesia.

Discussion

Trauma is estimated to complicate approximately one in twelve pregnancies, and is currently a leading non-obstetric cause of maternal death; moreover, maternal death remains the most common cause of fetal demise. Extensive multidisciplinary planning between the surgeons, intensivists, anesthesiologists and obstetricians is essential to ensure fetal and maternal well-being throughout the perioperative period. The anesthetic considerations of this case were many. We had a pregnant patient requiring spine fixation surgery in prone position. Her management was further convoluted by the associated injuries, most importantly multiple b/l rib fractures and small pneumothoraces.

Obstetric concerns

Optimum management requires a thorough understanding of normal maternal-fetal physiology, maternal physiologic adaptation to pregnancy and altered drug pharmacodynamics and pharmacokinetics. The increased oxygen requirements, decreased functional residual lung capacity and increased risk for aspiration associated with pregnancy complicates perioperative management by decreasing the time available and the margin of safety. These changes are extensively reviewed in many textbooks and review articles. The gestational age and maturity of the fetus as well as the acute maternal injuries were taken into account when formulating the operative plan. As the patient was in her second trimester, delivery of the fetus was not a feasible option. The obstetric team was consulted who advised fetal heart tones (FHT) monitoring pre and post operatively.

The deleterious effects of anesthesia on the human fetus have been considered for many years. As such, any drug has the potential to negatively affect the developing human fetus depending on the dose and the time of exposure and there is no “ideal anesthetic agent”.

Figure 1. A preoperative chest X-ray showing complete collapse of the left lung.
It is therefore most prudent to postpone elective surgical procedures until after pregnancy or, if possible, to avoid during the first trimester. There is no convincing evidence that any particular anesthetic drug at clinically used doses is clearly dangerous to the human fetus. Anesthetic goals are to prevent fetal asphyxia by maintaining maternal oxygenation, ventilation and hemodynamic stability and avoid factors that might cause reduction in the uteroplacental perfusion or compromise fetal gas exchange. Large survey studies on women who underwent surgery during pregnancy suggest no increase in congenital anomalies among their offspring but rather an increase in the risk for abortions, growth restriction for reasons mostly attributed to the requirement for surgery but not anesthetic administration. In our patient, we used a combination of intravenous (IV) anesthetics (propofol and remifentanil) with 1% sevoflurane in order to permit Somatosensory Evoked Potential (SSEP) and electromyogram (EMG) monitoring and allowed for rapid awakening at the end of the procedure. In clinical practice both propofol and remifentanil have been used safely in pregnant patients. Caution must be exercised while using propofol infusion for long procedures (>10 hours). Two cases of prolonged IV anesthesia with propofol during pregnancy (14–18 h) resulted in mild metabolic acidosis. Maintenance of normal maternal blood pressure is imperative because of the relative passive dependence of the uteroplacental circulation and also to avoid spinal cord ischemia. As such a reduction in maternal arterial pressure causes reduced uteroplacental blood flow and fetal ischaemia. We used phenylephrine infusion to maintain MAP above 70 mmHg based on the earlier studies supporting better maternal cardiovascular stability and improved neonatal acid-base status when phenylephrine was used to treat maternal hypotension. Alveolar ventilation increases by 25% to 30% during pregnancy. This increase results in chronic respiratory alkalosis with a Paco₂ of 28 to 32 mmHg and a slightly alkaline pH (approximately 7.44), and decreased levels of bicarbonate and buffer base. The Paco₂ should be kept in the normal range for pregnancy as both hyper and hypocapnia can compromise the fetus.

**Surgical positioning**

Some of the case reports and small case series have described good fetal outcome among gestational women who had spinal surgery during their pregnancy. Care must be taken while positioning the patient. There are well described and predictable changes in the fetus during their pregnancy. Some of the case reports and small case series have described good outcome for long procedures (>10 hours). Two cases of prolonged IV anesthesia with propofol during pregnancy (14–18 h) resulted in mild metabolic acidosis. Maintenance of normal maternal blood pressure is imperative because of the relative passive dependence of the uteroplacental circulation and also to avoid spinal cord ischemia. As such a reduction in maternal arterial pressure causes reduced uteroplacental blood flow and fetal ischaemia. We used phenylephrine infusion to maintain MAP above 70 mmHg based on the earlier studies supporting better maternal cardiovascular stability and improved neonatal acid-base status when phenylephrine was used to treat maternal hypotension. Alveolar ventilation increases by 25% to 30% during pregnancy. This increase results in chronic respiratory alkalosis with a Paco₂ of 28 to 32 mmHg and a slightly alkaline pH (approximately 7.44), and decreased levels of bicarbonate and buffer base. The Paco₂ should be kept in the normal range for pregnancy as both hyper and hypocapnia can compromise the fetus.

**Radiation exposure**

Additional consideration was also given to radiation exposure. Radiographic studies have shown that radiation exposure poses the greatest teratogenic risk in early pregnancy when organogenesis occurs (2–7 weeks). Exposure after organogenesis may cause growth restriction, microcephaly, and childhood cancer. Fetal risk of malformations is considered to be low with total radiation exposures of less than 50 to 100 mGy (5 to 10 rads). In contrasts to the negligible risk of teratogenicity, observational studies suggest that there is a slightly higher risk of childhood cancer at radiation doses greater than or equal to 10 mGy. Therefore, exposure to radiation should be minimized whenever possible. Computed tomography produces higher levels of radiation exposure than plain radiographs, but even abdominal and pelvic CT scanning usually produces estimated fetal exposures below those typically associated with adverse fetal/neonatal outcomes. In our case, CT-base image guidance was mostly used by the surgeons to limit the intra-operative fluoroscopy.
Conclusion
Successful surgical intervention was accomplished without any major morbidity or mortality due to thorough systematic assessment of individual issues and stratification of management priorities. The ultimate objective is to provide safe anesthesia to the mother while concurrently minimizing the risk of preterm labor or fetal demise. In our case, the patient was successfully discharged home and delivered a healthy baby at term without any complications.

Consent
Written informed consent for publication of their clinical details and/or clinical images was obtained from the patient.

References
This is a report of an exceptionally unusual presentation of a parturient with multiple trauma needing urgent neurosurgery. The authors do a thorough review of important aspects of parturient physiology, as well as the medical and surgical considerations involved. Still, the authors seem to have followed the typical care of any neurosurgical patient for this procedure and were just serendipitous in having a Jackson-type operating table with an open suspended sling that prevented any untoward pressure on the fetus or fetal circulation while in the prone position. If a more unique approach to neurosurgery or neuroanesthesia in the parturient was introduced and proven successful, this report would have much greater value to its readers.

The main scientific point is that the positioning and monitoring of a non-pregnant patient for neurosurgery serves well for the polytrauma pregnant patient for many reasons as well described, though not directly. Also missing is the inability to easily monitor the fetal status intraoperatively, and the inability to perform emergent cesarean delivery in this position if fetal distress occurs in a viable fetus. Are there modifications in the anesthetic or surgical approach that could accommodate these factors?

**Competing Interests:** No competing interests were disclosed.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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**Author Response 18 Jul 2015**

**Rashmi Vandse,** Ohio State University, Columbus, USA

We thank our reviewer for their input. We have modified the case report as suggested.

As the patient was in her early pregnancy, we did not have significant challenge in positioning her prone. Also since the fetus was non viable we didn’t encounter any need to modify her positioning.
As suggested in the literature, surgery in prone position has been carried out safely during the first and early second trimester. As pointed out by the reviewer, one of the drawbacks of prone positioning is inability to monitor fetal status or perform emergent cesarean section for fetal distress in a viable fetus. Spinal surgeries have been performed successfully under epidural anesthesia and lateral positioning has also been utilized safely during the late second and third trimester of pregnancy. These alternative surgical approaches must be discussed with the surgeon whenever feasible.

**Competing Interests:** No competing interests

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**Reviewer Report 10 July 2015**

https://doi.org/10.5256/f1000research.7153.r9420

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**Michael Paech**

School of Medicine and Pharmacology, University of Western Australia, Perth, Australia

This is a case report with an extended discussion of perioperative management in this setting. Although the patient was pregnant, she was in the early second trimester, when the relevance of some physiological changes of pregnancy and the absence of a distended abdomen or a viable fetus mean that the management is mainly specific to trauma issues - pregnancy issues are not well illustrated. Consequently the educational value of this report is diminished.

My main suggestions are:

1. Delete the sentence in the case presentation “On examination…..”

2. Add a sentence as to whether an attempt made to confirm fetal viability before and after surgery, and by what method.

3. The Discussion section on “obstetric concerns” is too long, a regurgitation of standard teaching and is not specific to this patient. This should be shortened. Likewise much of the first half on “surgical positioning” is not relevant to this patient.

4. Please check for quality of language. Examples of poor use include “of a pregnant patients”; “the obstetric team was consulted who…”; “multiple b/l rib……”; “3 of which…”

**Competing Interests:** No competing interests were disclosed.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.
We would like to thank our reviewer for reviewing our case report. We have modified it as per the suggestion. As pointed out by the reviewer, our patient was in her early 2nd trimester hence lacked the viable fetus or the distended abdomen. Physiologic changes of pregnancy are less pronounced. However as suggested in the literature, surgery during the early pregnancy carry increased risk for miscarriage and it is important to take all precautions to maintain adequate maternal oxygenation and hemodynamic stability which was complicated in our patient due to her polytrauma status.

1. Delete the sentence in the case presentation “On examination…..”- modified
2. Add a sentence as to whether an attempt made to confirm fetal viability before and after surgery, and by what method.- FHT were monitored both pre and post operatively which was reassuring.
3. The Discussion section on “obstetric concerns” is too long, a regurgitation of standard teaching and is not specific to this patient. This should be shortened. Likewise much of the first half on “surgical positioning” is not relevant to this patient.- Has been shortened.
   However some of the important obstetric issues have been retained for educational purposes. Surgical positioning – Has been shortened.
4. Quality of language has been checked and corrections have been made.

Competing Interests: No competing interests