Coordinating the Chaos Trauma Victim: The Unborn Neonate

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CASE STUDY

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ABSTRACT

Introduction: Prenatal traumatic injuries are rare. Our NICU team joined a multidisciplinary response to care for a mother post motor vehicle accident (MVA) and her injured fetus.

Case Presentation:

Main Symptoms: An emergent C-section was performed following non-reassuring fetal heart rate.

Main clinical findings: At birth, baby V. was flaccid, cyanotic and apneic with heart rate >100. Placental inspection indicated a partial abruption.

Maternal CT prior to delivery showed a fetal femoral fracture and intraabdominal hemorrhage.

Main diagnoses and interventions: Problems concerning baby V. included prematurity, femoral fracture, liver laceration, and adrenal hemorrhage, contributing to DIC. A UVC was placed for fluid resuscitation.

Endotracheal intubation was performed to enable ventilator support.

Multiple blood transfusions and stabilization of the femur fracture were required.

Main outcomes: Mother and baby recovered completely.

Conclusion: Poly-trauma requires immediate identification and prioritization of injuries and treatment. Collaboration between treatment teams was crucial in achieving successful outcomes.

Key Words: neonate; trauma; pulmonary hypertension; care coordination; team collaboration.

INTRODUCTION

Trauma is the leading cause of non-obstetrical maternal morbidity and death. Fetal mortality is reported to be as high as 73% in maternal trauma cases that involve penetrating abdominal and /or pelvic injury [1, 7, 8]. We present a case study in which we describe the initial emergent care of a mother post motor vehicle accident (MVA) and the subsequent care and management of her injured baby. All stages of this case management required multi-disciplinary team collaboration and communication,

problem solving and advance preparation that led to successful outcomes for both parties [2, 3, 6, 10-12, 14, 15].

Patient Information

First-responders' review of the accident scene concluded that the pre-dawn collision occurred at high velocity. A vehicle traveling the wrong direction struck an oncoming vehicle, throwing it onto its side. A 23 y/o pregnant female then struck the side-lying vehicle. When emergency medical services (EMS) arrived, they found her to be normotensive, alert and oriented. Her chief complaint was bilateral ankle and wrist pain.

Clinical Findings

She had sustained an abdominal wall degloving injury over the left iliac crest. "Degloving injury" is a term used to describe traumatic separation of full-thickness skin and subcutaneous tissue from an extremity or bony prominence, exposing the underlying bones, muscles and tissue. EMS notified our emergency department of the imminent arrival of a young adult gravid female with multiple injuries. EMS advised the ED that a 23 year-old female in her 33rd week of pregnancy had been involved in a motor vehicle accident with subsequent polytrauma. An ED system alert was activated to notify the ED staff, trauma team and obstetrics team who met in the trauma bay in the ED. Our NICU team then joined the other teams to await notification of need.

Leadership was initially provided by the adult trauma team in this resuscitation. With regard to pregnant trauma patients, primary consideration is always given to the emergent treatment of the mother, with secondary consideration given to the fetus. The premise is without survival of the mother, there is no survival of the fetus.

Her intake exam and initial imaging revealed multiple bone fractures and other traumatic injuries. See Table 1 for a complete list of maternal injuries.

A computed tomography (CT) scan of her abdomen was done to determine if internal abdominal injuries were present. During the CT scan, it was discovered that her fetus was in breech position and had sustained a displaced right femur fracture. Also, a concerning "blush sign" was seen in the fetus' abdomen. A "blush sign" is visualized pooling of contrast that is an indication of active bleeding seen during a CT scan. Additionally, the trauma surgeon was concerned for CT signs of a potential placental abruption.

In collaboration with the trauma team, the OB team focuses on the wellbeing of the fetus, and if needed, facilitates a safe preterm delivery.

The mother of this fetus was a 23 year old G2P0 who had good prenatal care. Her blood type was A positive with a negative antibody screen. Her group B strep status was unknown; her Hepatitis B surface antigen was negative; the rapid plasma reagin was non-reactive; human immunodeficiency virus was negative; rubella was immune; and gonorrhea/chlamydia tests were negative. Prenatal ultrasound (US) results were normal per OB records.

Initially, the obstetrical fetal assessment was reassuring, confirming a normal fetal heart rate and a fetal US that was negative for placental abruption. Continuous fetal heart monitoring was implemented to enable rapid intervention if fetal distress developed.

Fetal heart tracing displayed non-reassuring fetal heart rate when the mother received Propofol for a reduction of a fracture. With this information, the trauma surgeon was concerned for the well-being of both the mother and the fetus given the likelihood of a placental abruption, and maternal intra-abdominal injuries requiring surgical intervention. The decision was made in collaboration with the obstetrical team to deliver the fetus by emergent C-section.

Therapeutic Intervention

With the decision to proceed to the OR, all teams were coordinated. NICU team members were mobilized for resuscitation of the infant, the OB team prepared for the delivery and orthopedics were available for fixation of With the infant delivered, the trauma team continued with the mother's comprehensive management; including exploring

her abdomen for organ injury and closing the abdominal incision. Debridement of the iliac bone trauma site and fixation of multiple lower extremity fractures was then performed by the orthopedic team.

Follow-up and Outcomes:

Following baby V's extraction, he was flaccid and cyanotic with no spontaneous respiratory effort; his heart rate was over 100. He was dried and stimulated while continuous positive airway pressure (CPAP) was applied. When no spontaneous respiratory effort was observed for 30 seconds, positive pressure ventilation (PPV) was initiated in observance of Neonatal Resuscitation Program (NRP) guidelines initially with room air; then 40-50% supplemental oxygen was added to achieve target oxygen saturation goals. His heart rate improved to greater than 100 and the oxygen was gradually weaned. At this time he was intubated with a size 3.0 endotracheal tube due to insufficient intrinsic respiratory effort. An emergency umbilical venous catheter (UVC) was placed per NRP protocol and he received two normal saline boluses, each of 10 ml/kg. His Apgar's at 1 minute were 2 (2 for heart rate); and at 5 minutes were 5, (2 for heart rate, 1 for color, 1 for tone, and 1 for grimace); at 10 minutes the Apgar's were 6, (2 for heart rate, 1 for color, 2 for tone and 2 for grimace) (see table 2).

Table 3 summarizes baby V.'s medical issues in his first hours of life.

His tone and activity continued to improve as he was transported to the NICU in a heated transport incubator. His oxygen was weaned to 21% en route. Initial capillary blood gas result was a pH of 7.22, a PCO2 of 46, a PaO2 of 40, a bicarbonate level of 19 and a base excess of -9. He received a saline bolus to correct the metabolic acidosis. Mild anemia was evident on the complete blood count which indicated a hemoglobin level of 11 and hematocrit results of 33. Three hours later the blood gas result was a pH of 7.28, a PCO2 of 54, a PaO2 of 35, a bicarbonate level of 26, and a base excess of -2 with hemoglobin of 14 and hematocrit of 41.6. Possibly, the first values were diluted as the initial blood was drawn from an emergently inserted UVC after the saline bolus. Initially, the chest x-ray was consistent with mild respiratory distress syndrome (RDS). Surfactant was administered to baby V. to facilitate lung maturity and his respiratory status was further managed with multiple ventilator modalities.

Contrast from the mother was visualized in the infant's right kidney, which could not be completely visualized. An abdominal US was performed which showed a 1.3 cm liver laceration, adrenal hemorrhage and renal contusion with minimal free fluid in the abdomen. The blood pressure was decreased with a MAP of 28-30 and another 10 ml/kg normal saline bolus as well as 10 ml/kg of PRBC were infused.

Pain management for baby V. was a priority of care following the initial cardiopulmonary stabilization. He exhibited desaturation events when his right leg was touched or moved. Baby V. was given intermittent Morphine injections intravenously as well as a Morphine infusion. Opiate pain management remained active for fifteen days and was titrated utilizing the Neonatal Infant Pain Scale, (NIPS).

Upon maternal chart review, it appeared there was a partial abruption as evidenced by manual placental inspection. A Kleihauer-Betke (KB) test was positive. Kleihauer-Betke is a blood test performed using a maternal sample to estimate the amount of fetal blood cells that are present in the maternal circulation following a fetal-maternal hemorrhage.

Anemia was significant as internal hemorrhage losses with hypovolemic shock continued, requiring multiple packed red blood cell transfusions and careful administration of resuscitative crystalloid fluids and colloid products during the first few days of life. Managing and controlling baby V.'s internal hemorrhage was a challenge and the decision to administer factor VII versus packed red blood cells was determined with the collaborative effort of the pediatric trauma surgeon and our neonatology team.

Recombinant activated factor VII was administered, resulting in improved coagulation factors without further emergent blood product transfusions.

A cranial ultrasound performed on the day following delivery showed no intraventricular hemorrhage or intracranial hemorrhage, hydrocephalus or periventricular leukomalacia.

CT imaging of the mother's pelvis and abdomen shortly after she arrived in the ED clearly showed a displaced fracture of the right femur of the fetus. Radiographic imaging (see Radiographs) of baby V. after birth confirmed the displaced right femoral fracture as well as a closed left clavicular fracture.

Although the radiographic image of the femur fracture was visually impressive, and obviously painful, no surgical intervention or reduction was recommended by consulting pediatric orthopedic specialists. A Pavlik harness is often applied to support the lower extremity and hip as the fractured femur is healing, however baby V. was too small to fit properly in the smallest available harness device. Alternatively, he was double-diapered, and positioned with his hips abducted. While alignment was not optimal, the fracture site remained in the same plane, optimizing bone healing.

Baby V. was very fortunate to have been in breech position at the time of the MVA. Had he been in cephalic position, he likely would have sustained severe head trauma. He was discharged home with his mother 23 days after his birth. Follow up appointments have shown gratifying progress with uneventful healing of the femoral fracture. He is now bearing weight equally with both legs and is meeting all of his developmental milestones.

Discussion

According to Luley, trauma caused by accidents is common, occurring in 5-20% of all pregnancies.6 Research has shown that trauma is more likely to cause maternal death than any other medical complication of pregnancy with motor vehicle accidents as the mechanism for injury (MOI) in 21% of all instances of pregnancy trauma.

According to the National Highway Traffic Safety Administration (NHTSA) 1,500–5,000 fetal deaths each year are estimated to result from maternal involvement in motor vehicle accidents [7]. This MOI caused fractures to Mother V's lower extremities and wrists, as well as blunt abdominal trauma. In this case, maternal trauma caused significant secondary complications to the fetus. Collision physics involving the sudden acceleration-deceleration phenomenon caused shearing and tearing forces between the uterus and placenta. Due to the disruption of this interface, a partial placental abruption occurred, and was likely the mechanism for allowing a fetal-maternal hemorrhage.

Prematurity issues that complicated this case were Respiratory Distress Syndrome (RDS), Patent Ductus Arteriosus (PDA), and Persistent Pulmonary Hypertension (PPHN). These issues were managed by the neonatology team.

With regard to the conservative treatment approach of the liver laceration and subsequent internal hemorrhage; baby V. responded well to volume support and recombinant activated factor VII to facilitate hemostasis.

According to Coimbra et al, conservative management has shown an overall survival benefit and 23% reduction of mortality in blunt liver injury in the adult population, but no neonatal evidence is available [8]. Two other instances have been reported by Veldman, et al., using recombinant activated factor VII in premature neonates. In both cases, hemorrhage progressing to hemorrhagic shock was successfully controlled in the absence of pre-existing coagulopathies [17].

In normal term infants, at approximately 24 hours of life the pulmonary blood flow increases to 100% of the cardiac output and the pulmonary arterial pressure decreases to approximately 50% of the systemic arterial pressure [4, 5]. When this normal transition fails as occurred with Baby V. due to volume resuscitation, emergency C-Section and failure of pulmonary artery pressure to decrease, the sequelae is PPHN. PPHN occurs in approximately 2/1000 births and complicates the course of

approximately 10% of all neonates with respiratory failure [4, 5]. Baby V. was managed with inhaled nitric oxide (iNO) at 20 parts per million (ppm) and weaned as metabolic acidosis improved. iNO is not commonly used in the management of pulmonary hypertension in premature infants, although its use in this patient population is growing as more premature neonates with multiple complex physiological problems, often including pulmonary hypertension, are surviving the neonatal period [4, 5]

Precise and coordinated interventions of volume resuscitation, fluid management and pain control facilitated his ability to decrease pulmonary resistance over his course of recovery.

Team infrastructure and concepts

This particular case required focused teamwork for one trauma patient that subsequently became two and required interdisciplinary coordination of systems, teams, and individual management. Conceptualization of functional goals is necessary to achieve successful outcomes in complex situations that demand an organized teamwork system. All team members must actualize their role to function independently and interdependently within their distinct specialties [2, 9].

A good outcome was achieved in this particular case through coordination of multiple teams, strong communication, leadership, successful dynamics and practice sessions incorporating simulation to prepare response teams for complex, high risk circumstances [10].

Facilitating the development of high quality team management and minimizing human factors are key components of the TeamSTEPPS program [10]. TeamSTEPPS® is a program developed by the Department of Defense (DoD) patient safety program in collaboration with the Agency for Healthcare Research and Quality [2]. Concepts developed by this program were successfully utilized by our teams to address this challenging case. In this case situation, detailed communications, individual backup and support reduced secondary sequelae [6]. Team management, leadership skills, pre-briefing and debriefing, provided enhanced safety and decreased human error.

Currently, curricula in advanced health education does not prepare individuals to efficiently respond to complex emergencies while coordinating multiple medical specialties. Facility quality reviews and team coordination is a substantial part of on-site experiential learning for leadership teams [11]. These dynamics need to be organized and developed prior to the situational occurrence [12].

In 1999, preventable medical errors in the United States hospitals alone were estimated at costing 98,000 patient lives and between $17 to 29 billion every year as was determined by the Institute of Medicine (IOM) [13].

These errors are reducible by strong leadership skills, team development, coordination of care teams and by initiating methods of team training [2]. Teams at UCDH coordinate meetings to facilitate communication between multiple specialties. Team development is built on communication and leadership knowledge. Leaders must have an identified knowledge base, skill and ability to function in stressful situations, while analyzing complex human factors and behaviors [10]. Highly efficient team leaders and members as those involved in the resuscitation of this mother and infant dyad demonstrated a clear vision of the plan, utilized structured communication, adapted care plans rapidly in response to unstable and changing situations and collaborated with interdisciplinary teams to achieve their shared goal with optimal outcomes [2, 3].

Neonatal nurse practitioners, NICU nurses, and trauma nurse practitioner leaders are accessible and part of the team concept. They promote continuous goal commitment and demonstrate continued efforts to motivate their teams. This was clearly demonstrated by the team's commitment to the vision, focus on quality achievements, statistics and outcome data. Transformational leaders are people-oriented and believe in success, which comes from perseverance and deep commitment to change and improvement. This positive energy flows through passion and confidence, which is

supported by science, data and research methodology [14, 15, 16].

Summary

Creating a supportive team environment involves much work and anticipatory planning. Education and simulation classes and modules help develop strong situational leadership skills that promote the ability to direct and coordinate team members, assign roles, motivate team members facilitate optimal team performance [12]. Team leaders are able to clarify team roles, provide performance expectations, facilitate pre-briefing, and actively participate in team problem solving [2].

Advance planning for emergency cases, as portrayed in this case, reduces anxiety due to fear of the unknown and feeling unprepared. A team working together shares responsibilities and ideas. Pre-briefing is a time to discuss what is known, what can be anticipated, role assignment and prioritization of actions. De-briefing is a helpful review of what went well, what can be improved upon and also serves to relieve stress for team members.

Our team was challenged by a premature baby that was unable to receive prenatal steroids or neuroprotective medications. We were tasked with managing a tiny trauma patient that presented with emergent issues of hypovolemic shock, respiratory failure and pain that led to emergency resuscitation, protracted volume management, respiratory interventions and pain control. It was helpful to be advised to use recombinant activated factor VII in this case to resolve coagulation issues. Orthopedic advice and support led to the successful healing of a femur fracture without surgical intervention. Sharing in the success of the recovery and healing of this mother/baby duo was a valuable experience we will never forget. (Summary of Recommendations)

REFERENCES

1. Petron, P.; Talving, P. Browder, T.,Teixeira, P, Fisher, O., Chan, L.S., (2011) Abdominal injuries in pregnancy: a 155 month study at two level 1 trauma centers. Injury. 2011 Jan; 42(1): 47-9.

2. National Highway Traffic safety Administration retrieved http://www.nhtsa.gov/search?q=fetal+death&x=0&y=010

3. Coimbra R, Hoyt DB, Engelhart S, Fortlage D. Nonoperative management reduces the overall mortality of grades 3 and 4 blunt liver injuries. Int Surg. 2006; 91: 251–7.

4. Terra, M. (2015). Interdisciplinary Rounds: The Key to Communication, Collaboration, and Agreement on Plan of Care Professional Case Management. 20(6):299–307.

5. Luley T, Fitzpatrick CB, Grotegut CA, Hocker MB, Myers ER, Brown HL. Perinatal implications of motor vehicle accident trauma during pregnancy: identifying populations at risk. Am J Obstet Gynecol. 2013 Feb 21.

6. Wyckoff, M. (2013) Nursing Leadership and Management: The Advanced Practice Role Chapter 5. Understanding Leadership and the Role of Nurse Practitioners in Critical Care Settings and Chapter 9. Understanding the Role of Leadership and Critical Thinking Principles to Improve Patient Outcomes Editor D. Korniewicz, DEStech Publications, Lancaster PA 2013.

7. Salas, E. & Frush, K. (2013). Improving Patient Safety through team work and Team Training. Oxford University Press.

8. Miller, D.; Crandall, C; Washington, C. McLaughline, S. (2012) Improving teamwork and communication in trauma care through in situ simulations. Academic Emergency Medicine 19(5): 608-12.

9. Bass, B.M. & Bass, R. (2008) Handbook on Leadership: Theory Research and Managerial Application. New York: Free Press.

10. Bass, B. M. (1985). Leadership and performance beyond expectation. New York: Free Press.

11. Veldman, A., Fischer, Dl, Voigt, B., Beyer, P.A., Schlősser, R., Allendorf, A., and Kreuz, W., 2002. Life-threatening hemorrhage in neonates: management with recombinant

activated factor VII. Intensive care medicine, 28(11), pp. 1635-1637.

12. Chandrasekharan, P.; Kozielski, R., Kumar, V., Rawat, M., Manja, V., Ma, C. Lakshminrusimha, S. (2017). Early Use of inhaled nitric oxide in preterm infants: Is there a rationale for selective approach? American Journal Perinatology April; 34(5): 428-440.

13. Steinhorn, R. (2011). Pediatric Critical Care Medicine. Pediatr Crit Care Med. 2010 Mar; 11(2 Suppl): S79–S84.

14. Agency for Healthcare Research and Quality (AHRQ, 2008). The Quick Reference Guide to TeamSTEPPS® Action Planning: TeamSTEPPS® Implementation Guide. November 2012. Agency for Healthcare Research and Quality, Rockville, MD.

15. Baker DP, Gustafson S, Beaubien J, Salas E, Barach P. Medical teamwork and patient safety: The evidence-based relation.

16. Makary MA, Daniel M. Medical Error - the third leading cause of death in the US. BMJ 2016; 353: i2139.

17. Bass, B. M. (1990). From transactional to transformational leadership: Learning to share the vision. Organizational Dynamics, (Winter): 19-31.

Summary of Recommendations	
What is known?	The concept of multidisciplinary teams occasionally applies to multiple patients simultaneously Communication among multiple disciplines is the keystone to decrease complications and errors Utilizing skilled team leaders improves team communications
What needs to be studied?	Leadership within teams Communication between multiple disciplines in the care of hospitalized patients
What We Can Do Today?	Set clear expectations of who is the liaison within multiple disciplines The liaison may not be the person directing the care on the team, but rather a person with global insight

Tables

Table 1: Maternal Injuries.

Fractures	Soft tissue Injuries
Bilateral ankle fractures	Concussion
Lumbar transverse process fracture of L1 and L2	A seatbelt injury to the abdomen with a small soft tissue avulsion over the left iliac crest
Left iliac fracture	Multiple bruises
T3-T4 thoracic endplate fracture	Multiple contusions
Bilateral wrist fractures	
Fractured sternum	

Table 2: Apgar table.

Sign c	Score 0	Score 1	Score 2	Apgar's 1 minute	Apgar's 5 minutes	Apgar's 10 minutes
Heart Rate	Absent	< 100	>100	2	2	2
Respirations	Absent	weak	Good cry		2	2
Muscle Tone	Flaccid	Some flexion	Well flexed			1
Grimace	No Response	Grimace	Active			1
Color	Pale/blue	Blue Extremities	Pink		1	1
Total	0	5	10	2	5	7

Table 3: Baby V. Medical issues after birth.

Problems secondary to trauma	**Problems secondary to prematurity**
Hypovolemia	Gestational age 33 4/7 wks 2.2 kg
Right clavicle fracture	Respiratory distress requiring mechanical ventilation
Displaced right femur fracture	Immature lungs requiring surfactant therapy
Anemia due to internal hemorrhage	Persistent pulmonary hypertension
1.3 cm liver laceration of right posterior lobe	Evaluation of the newborn for infection
Adrenal Hemorrhage	Cardiac murmur
Kidney contusion	Hypotension

Figures