One Hundred and Fourteen Days of Somatic Support in a Severely Brain Injured Pregnant Woman: Case Report and Review of the Literature

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Abstract

The management of a previable pregnancy complicated by severe brain injury raises the question of whether to provide somatic support in order to maintain the pregnancy or not. Obstetricians who encounter this clinical scenario are faced with emotional, medical and ethical complexities, which require multidisciplinary input. A 19-year-old woman with an unremarkable medical history suffered severe brain injury and remained in a persistent vegetative state following a gunshot wound to the neck. She was discovered to be 15 weeks pregnant during resuscitative efforts. Following consultation with her family and power of attorney it was agreed to continue somatic support in order to maintain the pregnancy. A literature review to determine the best evidence based care from a multidisciplinary perspective is performed addressing issues of ethics, simulation and management of changes in maternal physiology, as well as pregnancy outcomes based on the neurological sequelae following severe brain injury. Previable pregnancies complicated by severe brain injury may be maintained until viability. Based on limited data, the obstetric outcomes may differ depending on whether the neurological sequelae are brain death or a persistent vegetative state. This management should be performed following consultation with the patient’s power of attorney in conjunction with the ethics committee and legal department of the hospital. Maternal physiological changes of pregnancy must be considered for successful somatic support.

Keywords: Previable pregnancy; Severe brain injury; Brain death; Persistent vegetative state

Introduction

Consciousness can be defined as the ability to experience or to feel, wakefulness, having a sense of selfhood, and the executive control system of the mind \cite{1}. Unconsciousness, which is the opposite, consists of 3 forms: coma, brain death and persistent vegetative state (PVS) \cite{2, 3}. All 3 forms can be caused by traumatic and atraumatic (for example, cerebrovascular accident, hypoxia, hypothermia, hypoglycemia intoxication and so on) brain injury, with the latter usually associated with poorer outcomes than the former \cite{2, 3}.

Coma is a state in which the patient cannot be aroused by any stimulus, however vigorous or painful. Thus, the patient in coma shows no response to any external stimulus or inner need and lacks both wakefulness and awareness. Brain death is the unequivocal and irreversible loss of all brain function. These patients have lost all brain stem functions and cranial nerve reflexes and are irreversibly comatose. In contrast to this, patients in a persistent vegetative state though lacking cerebral function still possess brain stem function for example swallowing and respiratory control. Clinically they can be observed to be awake as they still possess sleep-wake cycles. Table 1 summarizes the difference between these 3 forms of unconsciousness \cite{2, 3}.

It is unlikely that a pregnancy well beyond viability will be maintained following a maternal neurologic transition from consciousness to a persistent vegetative state or a brain death status secondary to a severe brain injury as a perimortem cesarean section is usually performed as part of the resuscitative efforts. However the same cannot be said for a previable pregnancy. The question of whether or not to provide somatic support may be associated with emotional, medical and ethical complexities, which require multidisciplinary input.

We present a case of an early second trimester pregnancy complicated by maternal PVS due to a catastrophic brain injury following a gunshot wound to the neck. In this case we describe the different medical modalities aimed at supporting the fetus via maintenance of maternal homeostasis and address the pertinent ethical and medical issues associated with this very rare complex obstetric situation.
Case Report

A 19-year-old African American female with an unremarkable medical, surgical or obstetric history was brought into the emergency room within 3 - 4 min after suffering a gunshot injury to the neck during a drive-by shooting. She was observed to be unresponsive and exsanguinating from the injury site. The bleeding was abated by insertion and inflation of a Foley catheter at the bleeding site. Cardiopulmonary resuscitation was performed following a finding of complex sinus bradycardia. Endotracheal intubation was performed as a part of the resuscitation effort. A 15-week pregnancy was discovered during initial assessment. She received epinephrine and atropine during resuscitative efforts. During surgical neck exploration a massive hematoma was found in the neck encircling the right internal jugular vein and a paracervical hematoma posterior to the esophagus. Tracheostomy and percutaneous endoscopic gastrostomy tubes were placed to facilitate breathing and enteral feeding respectively. Computer tomography (CT) of the neck showed a comminuted fracture of C6 with posterior displacement of a fragment into the cervical canal with spinal cord compression and occlusion of the left vertebral artery. A computer tomography scan of the brain showed global cerebral edema with herniation and radiological evidence of hypoxic ischemic encephalopathy.

Following initial resuscitative and surgical care a full systemic examination revealed an unresponsive young pregnant female with spontaneous eye opening, intact corneal and pupillary reflexes, a weak gag reflex and absent rectal tone. The patient was thus designated as being in the vegetative state from acute severe cerebral hypoperfusion with quadriplegia secondary to the gunshot wound (GSW) to the neck. She required ventilatory support in the surgical intensive care unit (SICU).

The presence of a previable pregnancy in a patient in the vegetative state prompted consultation of the hospital ethics committee and legal department. A meeting to determine direction of care was convened with the patient’s family members, maternal-fetal medicine specialist and the primary care team (SICU), and ethics committee. During this meeting it was discovered that the pregnancy was concealed. After extensive counseling about patient’s medical condition the family elected to continue life support and insisted that every effort be made to continue the pregnancy. This decision was made with the understanding of the increased risk for adverse pregnancy outcome secondary to maternal-fetal hypoxia, multiple medication and radiation exposures, the anticipated multiple maternal infections and the risk of extreme prematurity. The patient’s family elected her mother as legal guardian and power of attorney for all future decisions. The primary management team (SICU) was counseled to balance the risk-benefits of further radiological exposure and to carefully select maternal medications.
Prenatal labs were within normal limits except for a chromosomal aneuploidy quad screen that placed the fetus at a 1:92 risk for Down syndrome. Her legal guardian declined an amniocentesis and an anatomy ultrasound performed at 19 weeks gestational age revealed no classic ultrasound findings (“soft markers”) consistent with Down syndrome or any other anomalies except for a single umbilical artery. Weekly clinical assessment was performed by the maternal-fetal medicine unit with daily fetal heart tones check, which was changed to twice daily non-stress tests at 30 weeks gestational age. The patient was nursed with left abdominal tilt at all times to maximize uteroplacental perfusion.

Hospital days (HDs) 5, 25, 35 and 53 were complicated by maternal fever secondary to recurrent urinary tract infection and then bacteremia with *Enterococcus* species that was managed with appropriate antibiotics and subsequent administration of urologic antibiotic suppression. She required multiple bronchoscopies to suction mucus plugs which led to left sided lung collapse. On HD 81 she received a blood transfusion secondary to anemia. After an episode of complicated staphylococcal pneumonia, antenatal corticosteroids for fetal lung maturity were administered on HD 111 (31 weeks gestation).

Spontaneous rupture of membranes with the onset of preterm labor was identified at 31 weeks and 2 days gestation. Continuous fetal monitoring was commenced and 8 hours after she was in the second stage of labor. A Simpson forcep was used to shorten the second stage of labor after the fetal head descended to +3 station. A live male infant with a birth weight of 1,740 g with an Apgar score of 9 in 5

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**Table 2. Important Maternal Physiologic Changes in Pregnancy** [35, 36, 57, 58, 60]

<table>
<thead>
<tr>
<th>Organ system</th>
<th>Measured parameter</th>
<th>Direction of change</th>
<th>Values in normal pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>Minute ventilation</td>
<td>Increases 50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oxygen consumption increases</td>
<td>Increases 20%</td>
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<tr>
<td></td>
<td>FRC</td>
<td>Decreases 20%</td>
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<td></td>
<td>Arterial PCO2</td>
<td>Decreases</td>
<td></td>
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<tr>
<td></td>
<td>Serum bicarbonate</td>
<td>Decreases</td>
<td>28 - 32 mmHg</td>
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<td></td>
<td>Chest wall compliance</td>
<td>Decreases</td>
<td>18 - 21 mEq/L</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Cardiac output</td>
<td>Increases 50%</td>
<td>6.2 ± 1.0 L/min</td>
</tr>
<tr>
<td></td>
<td>Blood volume</td>
<td>Increases 30-50%</td>
<td></td>
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<tr>
<td></td>
<td>Heart rate</td>
<td>Increases by 15-20%</td>
<td>83 ± 10 beats/min</td>
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<tr>
<td></td>
<td>SVR</td>
<td>Decreases 20%</td>
<td>1,210 ± 256 dynes/sec/ cm²</td>
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<tr>
<td></td>
<td>COP</td>
<td>Increases 15%</td>
<td>18 ± 1.5 mmHg</td>
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<tr>
<td></td>
<td>PCWP</td>
<td>Decreases</td>
<td>7.5 ± 1.8 mmHg</td>
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<td></td>
<td>Aortocaval compression</td>
<td>Increases</td>
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<tr>
<td>Hematologic</td>
<td>Clotting factors I, VII, VIII, IX, X</td>
<td>Increases</td>
<td></td>
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<tr>
<td></td>
<td>Protein C and S</td>
<td>Decreases</td>
<td></td>
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<tr>
<td>Gastrointestinal</td>
<td>Motility</td>
<td>Decreases in both</td>
<td></td>
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<td></td>
<td>Lower esophageal sphincter</td>
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<tr>
<td>Renal</td>
<td>Compensated respiratory alkalosis</td>
<td>Increases in both</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glomerular filtration rate</td>
<td></td>
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</tbody>
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FRC: functional residual capacity; SVR: systemic vascular resistance; COP: capillary osmotic pressure; PCWP: pulmonary capillary wedge pressure; vWF: von Willebrand factor.
injury while trauma is responsible for < 1% of hospitalizations in pregnancy [4]. In addition, trauma accounts for almost 4% of maternal mortality and 9% of fetal mortality [5]. However, on reviewing the literature (including this case), there is an equal frequency of traumatic and atraumatic etiologies for the occurrence of PVS in a pregnant woman [4-21]. As expected, there is a disparity favoring an atraumatic etiology in pregnant patients with brain death [22-31].

The physician faced with the dilemma of pregnancy in a patient in either the vegetative state or brain dead must consider whether to 1) attempt delivery of the fetus if past the age of viability; 2) immediately discontinue life support measures with the knowledge that this will lead to fetal death; or 3) like in our case continue full life support measures in an attempt to prolong the pregnancy with the aim of achieving further fetal maturity. Unfortunately, the wishes of the victim of this catastrophic event are almost never known. Thus the decision of which path to follow in the care of these patients should be taken after careful and exhaustive consultation with her family, the hospital ethics and legal departments. Some authors who have addressed this issue in brain dead individuals recommend involving the next of kin—usually the father of the fetus in the decision making [22, 32, 33]. Others have proposed a hierarchy for surrogate decision in descending order of: 1) an individual designated verbally or in writing in an advance directive or durable power of attorney for healthcare decisions; 2) a guardian authorized by the courts; 3) the spouse; 4) an adult child or adult children of the patient; 5) parent or parents; 6) an adult sibling; and 7) any other blood relative [13]. In a situation where there is a difference of opinion on how this patient should be managed due to family conflict or rift, the legal department of the hospital should be involved with recourse to the judicial system to nominate a surrogate decision maker.

In the event that the family or surrogate decision-makers choose to continue life support measures and continue the pregnancy, it is imperative that the providers determine whether the brain injured unconscious patient is brain dead or in a vegetative state. This is important because, unlike the patient who is brain dead, the patient in PVS has the possibility of recovery. Data from the multi-society task force on PVS show that 52% of adults recover consciousness within 1 year, with a majority of these occurring within the first 6 months. Recovery after 6 months is usually unlikely [2, 3]. Thus somatic support in a pregnant woman in a persistent vegetative state is intended to preserve basic body functions with the possibility (although sometimes remote) of maternal recovery in addition to preservation and or maturation of the unborn fetus. This is in contrast to the pregnant woman who is brain dead for whom somatic support is only advantageous to the fetus [34]. Another reason to differentiate between PVS and brain death is that based on published literature, there is a significantly longer interval between maternal brain injury and delivery, which in turn results in higher gestational ages and birth weights at delivery when the PVS group is compared to the brain dead group [9]. The aforementioned information should be explained to patient’s family or surrogate decision-maker in order for them to make an informed decision.

Based on the type of neuropathology, a pregnancy complicated by PVS generally may require less somatic support than its brain dead counterpart. However PVS during pregnancy may require medical management close to the care received by a pregnancy complicated by brain death. This case was complicated by transection of the spinal cord at the cervical spine level, compromising innervation of the maternal diaphragm. Thus explain the need for prolonged mechanical ventilation.

In providing somatic support, the normal physiologic changes of pregnancy should be considered and attempted to be replicated. Changes in maternal physiology for consideration are summarized in Table 2 and addressed below.

Cardiovascular system

In a normal pregnancy the cardiac output is increased by 50% from the non-pregnant state with the uterus receiving about 30% of this increment [35, 36]. On admission to the emergency room this patient required cardiopulmonary resuscitation due to a finding of complex sinus bradycardia, which is usually associated to hypotension. Hemodynamic support is critical to maintaining adequate uteroplacental perfusion, which in turn is vital to fetal survival as uterine blood flow lacks auto regulation. The management of hypotension will require intravenous fluid infusion (including blood transfusion) and possible inotropic medications in addition to vasopressors. The American Heart Association guideline for cardiopulmonary resuscitation does not modify or change the type or dosage of medications used in resuscitation of pregnant women [37]. In addition, defibrillators can
be utilized without significant complication to the fetus [38]. Thus intravascular volume should be maintained and central venous pressure or pulmonary artery occlusion pressure measurements may be utilized for its surveillance [39]. The PVS patient should be nursed with a left abdominal tilt to avert supine hypotension syndrome. The possibility of low oncotic pressure due to suboptimal nutrition should be kept in mind and as such volume expansion should be with a combination of crystalloids and colloids [40].

Respiratory system

Respiratory support in the mode mechanical ventilation may be pivotal to supporting life in patients like in this index case. Usually the preservation of brain stem activity dictates that PVS patients require less respiratory support than their brain dead counterparts. Our patient required mechanical ventilatory support due to the mechanism of her injury and respiratory complications, which led to lung collapse. Although the fetus possesses mechanisms to avert hypoxia, adequate maternal oxygenation is pivotal as threshold for maternal hypoxia is significantly increased in pregnancy due to increased oxygen requirement and minute ventilation and reduced functional residual capacity [35, 36]. It is also important to consider and maintain the fetal CO₂ diffusion gradient by maintaining the maternal PaCO₂ at between 28 - 31 mmHg [41] which is lower than what is expected in non-pregnant individuals [42]. The risk of respiratory alkalosis which can lead to uterine hypoperfusion must be taken into consideration [43].

Endocrine system

Panhypopituitarism due to disruption of the hypothalamic-pituitary axis is the usual cause of an abnormal endocrine milieu in the severely brain injured individuals who later progress to brain death [39] or a persistent vegetative state [10]. This may lead to reduced production of antidiuretic hormone (ADH), cortisol and thyroxine. Central diabetes insipidus (CDI) is a common endocrine anomaly in both PVS and brain dead patients receiving somatic support [10, 39]. Polyuria and hypernatremia from CDI if uncorrected may result in constriction of intravascular volume which in turn may lead to uteroplacental underperfusion and its attendant complications. This can be corrected by administration of vasopressin intranasally, intramuscularly or intravenously. Correction of hypothyroidism to avert abnormal brain development cannot be overemphasized and this correction with that of reduced serum cortisol by hormone replacement should be guided by measurement of thyroid and adrenal function. In replacing cortisol it may be safer to utilize hydrocortisone or prednisone instead of betamethasone and dexamethasone as these glucocorticoids are not inactivated by placental 11β-hydroxysteroid dehydrogenase type 2 enzyme [44, 45] and prolonged exposure to them have been associated reduced fetal birth weight [46, 47], as well as adverse metabolic [48, 49] and neurologic [50, 51] effects in both animal and human studies.

Nutrition

Nutritional support is an integral part of the somatic management of these types of patients. Sampson and Petersen reported a weight loss of almost 20 lbs in the first 4 weeks of hospitalization of a pregnant PVS patient [18]. The Institute of Medicine recommends that a normal pregnancy should achieve a weight gain of 11.5 - 16 kg (25 - 35 lbs) [52]. Furthermore, some authors based on clinical experience have advocated for daily calorie intake of 3,000 - 4,000 kcal to avert nutritional deficiency in these patients [53]. Nutritional support can be achieved by enteral (which was performed in our patient-percutaneous enterogastrostomy), parenteral or both. Thus based on the aforementioned, daily weight measurement should be part of supportive care. Supplementation of vitamins and trace elements is important as shown in our patient whose care was complicated by anemia.

Infectious morbidity and temperature regulation

Fever usually heralds this complication. However hypothalamic damage may be the cause of a labile hyperthermia. Nonetheless, the potential source and type of infection should be aggressively investigated. As well as most intensive care type patients, urinary tract infection and pneumonia are the most common infections [54]. These morbidities affected our patient. Adverse neurological fetal effects of hyperthermia are well known [55] and as such antipyretics as well cooling blankets in addition to pregnancy-appropriate antimicrobials should be administered to these patients. Although hyperthermia can occur due to hypothalamic dysfunction in these patients, hypothermia is far more common and this has been shown to be associated with altered breathing pattern and fetal bradycardia in animal models [56]. This can be managed with warming blankets which have been shown to reverse the aforementioned adverse fetal effects in the same animal studies [56].

Other measures of optimizing fetal outcomes

It is important to perform a detailed anatomy ultrasound scan to determine the presence or absence of fetal anomalies and to also examine for features that might be associated with chromosomal abnormalities. This should be followed by appropriate screening and diagnostic studies. These findings may alter the request to maintain or prolong pregnancy if viability has not been attained. Regular fetal monitoring by nonstressed testing should be performed on daily basis when the fetus achieves viability. In addition the providers may
decide to administer antenatal corticosteroids at viability or when there is an increased risk for preterm delivery like in this case when the patient developed pneumonia. Routine gestational age indicated laboratory testing as in the conscious patient should be performed as specific optimizing interventions may be indicated based on these results.

Pregnancy being a hypercoagulable state due to alterations in certain clotting factors [57, 58] increases the frequency of venous thromboembolism 5 times more than the non-pregnant woman [59, 60]. Thus the need for adequate prophylactic anticoagulation in the recumbent immobile brain dead pregnant woman or one in a persistent vegetative state cannot be overemphasized.

**Conclusion**

To our knowledge this is only the 19th reported case of a pregnancy complicated by PVS and the 6th in which a vaginal delivery was performed. Given the paucity of available data, in this report we detail interventional strategies based on literature review and recognized pregnancy-specific physiologic considerations. When faced with this clinical scenario, the physician must determine whom the designated surrogate decision-maker is and if the patient’s wishes were known prior to the event. The form of unconsciousness must also be determined as data in the literature show significant differences in maternal and fetal outcomes based on whether the brain injury led to PVS or brain death. The obstetric team in conjunction with the intensive care unit should attempt to maintain and or simulate pregnancy physiologic homeostasis.

This case as well as others before it, shows that with optimal somatic support, it is possible to maintain a previable pregnancy and achieve delivery (albeit prematurely) with minimal short and long-term neurological disabilities in the fetus.

**Conflict of Interest**

Authors report no conflict of interest.

**References**


