Severe traumatic neurological injury to a mother during pregnancy can have deleterious effects on the fetus, yet several reports point out the possibility of achieving good fetal outcome after somatic support of the mother in conditions of brain death and persistent vegetative state. The tradition of acting on behalf of the fetus in conditions of maternal death has been present in many cultures, including Egyptian, American Indian, Persian, Oceanic, Hindu, and Patagonian. In the 8th century BC, the Roman kings established a Lex Caesarea that indicated that if a pregnant woman died, the infant should be excised as quickly as possible for baptism or for burial apart from the mother. If a severe TBI has not caused brain death or not yet resulted in a persistent vegetative state, the management decision may be more complex, and the options afforded by modern medical practice provide treatment paradigms that offer lifesaving interventions both for the mother and the fetus. Complexity lies in the fact that young adult mothers have better outcomes following severe TBI, which suggests that the use of maximal intervention, including surgery if indicated, be encouraged. In the case presented here, the traumatic injury experienced by the mother was severe enough to expect a poor neurological outcome. Another complicating issue was the young age of the fetus (21 weeks), which is below that defined for fetal viability. Neurosurgical intervention was required to save the mother and to maintain the fetus until viable.

Case Report

History and Examination. This 21-year-old woman was involved in a highway-speed, head-on motor vehicle crash. She was intubated at the scene without the use of paralytic or sedative agents after prolonged extrication from the vehicle. Neurological examination on arrival to the emergency department revealed that if a pregnant woman died, the infant should be excised as quickly as possible for baptism or for burial apart from the mother. If a severe TBI has not caused brain death or not yet resulted in a persistent vegetative state, the management decision may be more complex, and the options afforded by modern medical practice provide treatment paradigms that offer lifesaving interventions both for the mother and the fetus. Complexity lies in the fact that young adult mothers have better outcomes following severe TBI, which suggests that the use of maximal intervention, including surgery if indicated, be encouraged. In the case presented here, the traumatic injury experienced by the mother was severe enough to expect a poor neurological outcome. Another complicating issue was the young age of the fetus (21 weeks), which is below that defined for fetal viability. Neurosurgical intervention was required to save the mother and to maintain the fetus until viable.

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History and Examination. This 21-year-old woman was involved in a highway-speed, head-on motor vehicle crash. She was intubated at the scene without the use of paralytic or sedative agents after prolonged extrication from the vehicle. Neurological examination on arrival to the emergency department revealed that she had fixed and dilated pupils, no eye opening, and no response to pain (Glasgow Coma Scale Score 3). Primary survey revealed a right frontal scalp laceration with palpable underlying skull fracture. Bedside ultrasonography revealed a right frontal scalp laceration with palpable underlying skull fracture. Computed tomography images of the patient’s head (Fig. 1) and chest, abdomen, and pelvis (Fig. 2) were obtained. Imaging revealed a biconal skull fracture crossing the superior sagittal sinus (Fig. 1A), contusions of both frontal lobes, and areas showing early evidence of ischemic injury (Fig. 1B).

Treatment. After undergoing cranium to pelvis CT imaging, the patient was taken to the operating room for further evaluation. The maternal fetal medicine team determined that the fetus was viable at 20 weeks, 5 days’ gestational age; however, emergent cesarean section was not recommended as the fetus was not in distress. The...
neurosurgical team determined that emergent cranial surgery was not indicated. A fiberoptic ICP monitor was placed, and the patient was transferred to the intensive care unit after cleaning and closing her scalp laceration.

Upon arrival in the intensive care unit, the patient had a gag reflex, but other cranial nerve reflexes were absent. She withdrew minimally with painful stimulation of the extremities (nail bed pressure). Her pupils, which had been large and fixed on initial examination, reduced in size but were never reactive to light. Over the next 12 hours, maximum medical management was required (sedation, hyperventilation, hypertonic saline, multiple doses of mannitol, and chemical paralytics) to maintain the patient’s ICP within normal limits ($< 20 \text{ cm H}_2\text{O}$). Ultimately, these methods of nonsurgical management eventually failed to control ICP.

The situation was thoroughly discussed with the patient’s family who requested that every possible intervention be attempted in the hope of survival and improvement for both the patient and fetus. The hospital’s ethics specialists determined that there was precedent to follow the family’s wishes for maximal intervention in the interest of the fetus as well as the patient. The patient was taken to the operating room for bifrontal decompressive craniectomy to alleviate the elevated ICP.

Posttreatment Course. Postoperatively, the patient reached a steady state of consistently poor neurological examination, with tracheostomy and gastrostomy tubes in place. At 26 weeks, 2 days’ gestation the fetus was delivered via classic cesarean section because of maternal pre-mature rupture of membranes. The newborn had Grade III intraventricular hemorrhage and required CSF diversion by placement of a ventricular access device, which was replaced with a ventriculoperitoneal shunt when the child reached the appropriate size. Follow-up examination at nearly 9 months of age revealed a healthy, active child with a functioning shunt.

The mother experienced continued autonomic nervous system deregulation and required complete care for support of her daily needs. In addition to her neurological injury, she experienced bilateral mandible fractures (sustained at the time of initial injury), respiratory failure, malnutrition, deep venous thrombosis, and severe spasticity. When clinically indicated she underwent autologous cranioplasty and was subsequently discharged to an intermediate care facility when she no longer required an acute level of care. At the time of this writing, she remains in a persistent vegetative state.

Discussion

Multiple considerations exist when deliberating the futility versus the benefit of continued supportive measures and treatment of a pregnant patient with severe head injury. Such considerations include the best interests of the patient and, in certain cases, the best interests of the fetus.6,11 Neurological surgeons and other medical professionals find themselves in a difficult position because of these two potentially competing interests. However, we present the case of a 21-year-old woman who sustained a severe TBI while pregnant with a fetus at 21 weeks. The woman’s TBI was severe and devastating, and outcome predictions were poor; however, given her young age and the protective benefit of the intervention to the fetus, the family elected to proceed with maximal possible intervention, which was ultimately surgery. We cannot rule out the possibility that the family, who expressed their desire for these interventions, would have expressed the same desire had the patient not been pregnant.

Medical management using interventions and medications that were safe for the fetus failed to keep the mother’s ICP within safe limits. To save the patient’s life through controlling ICP without excessive sedation and to avoid injury or death to the fetus, the patient was taken to the operating room for bifrontal decompressive craniectomy. Evidence suggests that decompressive craniectomy is more effective in controlling ICP than medical treatment, but with a higher percentage of patients having unfavorable outcomes among survivors.1 As predicted, decompressive craniectomy provided the needed ICP control, and both the patient and the fetus survived. Previous reports have suggested a potential ethical dilemma in similar situations regarding brain death and persistent
Craniectomy in a pregnant woman with severe TBI

vegetative state. In the case we describe, however, the patient was not brain dead and surgery was an option, regardless of the fetus of not-yet-viable gestational age.

In cases in which the mother has sustained nonsurvivable TBI, the fetus may be delivered immediately, followed by the allowance of maternal somatic death. This situation has precedent in antiquity. What is less clear is what should be done when the fetus is too young for survival postdelivery and the mother sustains a nonsurvivable brain injury. Even less clear is what should be done when the mother has a potentially survivable brain injury and there is question of surgical intervention for the management of ICP. The literature contains reports of maternal somatic support until the fetus is predicted to be of a gestational age sufficient for survival postdelivery. The youngest reported gestational age at the time of maternal brain injury was 13 weeks, although in that case the fetus became nonviable 8 days after maternal brain death.

Ideally, surgical indications are based on a single patient; however, in the types of cases featured in this report, a surgical decision that is good for the mother may not be good for the fetus and vice versa. This situation applied in the case we present with regard to ICP management, sedatives, and the possibility of anesthetic administration. Neuronal cell death after neonatal exposure to various sedatives and anesthetics has been clearly demonstrated in developing animal models. Although the relevance for human patients remains speculative, the phenomenon’s potential serious implications warrant consideration. Likewise, interventions to optimize the homeostasis of the fetus might lead to elevated ICP in the mother since the traumatized brain has lost its autoregulatory capabilities. Therefore a balance between maternal and fetal treatment was necessary and was thought best achieved by performing a decompressive craniectomy.

The case we present was more difficult than some, considering the patient was not brain dead on presentation but was predicted to progress to brain death or even persistent vegetative state if maximal neurosurgical intervention and aggressive treatment of the ICP was not undertaken urgently. Maternal death would compromise the life of the fetus, which was clearly undesirable to the patient’s family. We relied on the family’s wishes and precedent in the literature to support the course of action taken. This was a situation involving, in essence, a potential sacrifice of maternal quality of life in favor of nonguaranteed fetal well-being (there was evidence of intraventricular hemorrhage). The trade of maternal quality of life for what can be an uncertain fetal quality of life is a potentially controversial issue with no straightforward answer. In this case, we argue that the alternative choice of not treating the ICP surgically could have resulted in the loss of the lives of both the mother and the fetus. The course we ultimately pursued resulted in a functional child, albeit with a ventriculoperitoneal shunt, and a mother who continues in a persistent vegetative state.

In future similar cases, we find no contraindication to undertaking surgical intervention for ICP management, and we suggest consideration of surgery even earlier than in the nongravid patient to provide ICP control while avoiding interventions potentially harmful to the fetus.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Ragel, Whitney. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Ragel. Study supervision: Ragel.
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