Liver lacerations as a complication of CPR during pregnancy

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Keywords: Obstetrics, Pregnancy, Cardiopulmonary Resuscitation, Cardiac Arrest, Complications (CPR), Liver Laceration, Liver Injury
Abstract

Aim: Cardiac arrest in peripartum patients is a rare but devastating event; reported rates in the literature range from 0.019% to 0.0085%. In the general population, a well-described complication of cardiopulmonary resuscitation (CPR), liver laceration and injury, is reported at a rate of between 0.5-2.9% after CPR. Liver laceration rate among peripartum patients receiving CPR has not been well-studied. We sought to find the rate of liver lacerations in the peripartum population associated with CPR, with the hypothesis that the rate would be higher than in the general population.

Methods: We identified pregnancies complicated by cardiac arrest by performing a retrospective medical record review from 2011-2016 at a single tertiary referral hospital. We then compared the rate of liver lacerations in this group to the rate in the general population as found in the literature.

Results: Eleven of 9408 women in the peripartum period suffered cardiac arrest. Return of spontaneous circulation occurred in seven of eleven (64%) women. Three of these seven women suffered clinically significant liver laceration (43%). Overall mortality rate among women suffering cardiac arrest was 82% (9/11). Even after return of spontaneous circulation, the mortality rate was 72% (5/7) including two of three women suffering liver laceration.

Conclusions: Based on a small retrospective study, liver lacerations requiring intervention occurred in 43% of gravida patients that survived CPR, and is significantly higher than published rates (0.6-2.1%) for the general patient population. Further studies are indicated to determine if this rate of liver injury associated with peripartum CPR.
Introduction

Maternal cardiac arrest is a rare, frightening and devastating event, often resulting in the demise of the mother, fetus/neonate or both. The most common cause of maternal cardiac arrest is haemorrhage, accounting for up to 40% of all cases. The reported rate of CPR among the peripartum population within developed countries ranges from 1:53,260 (0.019%) to 1:11,749 (0.0085%).

Cardiopulmonary resuscitation (CPR) is an important intervention that has improved survival after cardiac arrest since being described almost 60 years ago. Due to the physiologic changes that occur in pregnancy, guidelines for BLS/ACLS in the pregnant patient have been modified; for example, closed chest compressions are performed while manually displacing the gravid uterus to the left to alleviate compression of the vena cava and chest compressions are focused slightly higher on the sternum. However, exact hand placement is not specified and it is unknown if most responders are aware of this alteration. In addition, in the absence of a return of spontaneous circulation (ROSC) within four minutes, immediate perimortem cesarean delivery (ameliorating caval compression) is indicated to achieve optimal maternal outcome.

Though the liver is often congested due to a lack of venous return during cardiac arrest, the rate of liver injury in the general population after CPR is low. In pregnancy, hepatic congestion in addition to other physiologic changes are reported. While an enlarged liver in pregnancy is only reported in patient with prior liver disease, a more palpable liver immediately postpartum has been reported.

We hypothesized that chest compressions performed on pregnant and “early postpartum” patients are associated with an increased rate of liver lacerations during CPR as compared to the general population. Our primary objective was to determine the rate of liver laceration as a complication of CPR in pregnancy.

Methods

Using a protocol approved by our institutional review board (HP-0071605), a retrospective case review was performed at the University of Maryland Medical Center (UMMC) from 2011-2016. Cases of CPR performed on peripartum women, including transfers from other
hospitals, were identified both by inspection of obstetric, anesthesiology, and trauma databases and by query of UMMC discharge records, using codes: arrest (475.5) and pregnancy (v22.1). Patient demographics and details surrounding each cardiac arrest event including post-CPR complications were then gathered. Inclusion criteria were pregnancy (from 20 weeks’ gestation to one year postpartum), suffering a cardiac arrest and CPR. Exclusion criteria included known prior liver injury or disease. Records were reviewed to determine liver injury after CPR.

The total number of peripartum women with cardiac arrest who receive CPR was divided by the total number of deliveries at UMMC from 2011-2016 to determine the period prevalence of CPR in pregnancy. The number of women with liver injury associated with CPR in pregnancy was divided by the previously determined total number of pregnancies complicated by cardiac arrest and CPR to determine the period prevalence of liver injury associated with CPR in pregnancy. A thorough literature review was performed to identify the rates of CPR as well as any published rates of liver injury from CPR both in the general population and in pregnant women.

Results

Including transfers to UMMC during 2011-2016, eleven cases of cardiac arrest and CPR in peripartum women were identified out of 9,408 deliveries at UMMC. All eleven women met inclusion criteria (Table 1). Return of spontaneous circulation occurred in 7 of the patients (64%). Overall mortality was 82%. The period prevalence of cardiac arrest among all deliveries at UMMC during this six-year span was 0.12% (1:855). Liver lacerations occurred in three of the eleven women. The period prevalence of liver injury associated with CPR in pregnant women at UMMC was 27%, and was 43% amongst survivors of CPR. All three of these women suffered clinically significant liver lacerations, only one survived (Table 2).

Case 1

A 34-year-old G6P3, presented to Labor & Delivery at 31 weeks’ gestation with abdominal pain and leakage of fluid. She had a history of diabetes mellitus (type 1), hypertension and chronic kidney disease. Her calculated BMI was 25 m²/kg. She was diagnosed with preterm premature rupture of membranes. She was started on magnesium sulfate and steroids were administered. Shortly after administration of the magnesium, she became unresponsive and it
was thought she had a seizure. Immediately following emergent delivery by cesarean section, the patient experienced cardiopulmonary arrest and ACLS was started. ROSC occurred fifteen minutes later. Massive abdominal haemorrhage continued after closure of the uterine incision; a hysterectomy was performed. She continued in shock despite massive transfusion and intravenous infusion of vasopressors. Further abdominal exploration revealed liver injury, including a: large (right lobe) subcapsular hematoma; laceration adjacent to the gallbladder; and, separate left infra-lobar laceration. Her postoperative course deteriorated further in the intensive care unit (ICU). Despite heroic measures, she remained unresponsive with evidence of brain death, expiring after termination of further resuscitative efforts.

**Case 2**

A 35-year-old G3P2 presented to an outside hospital (OSH) at 38 weeks’ gestation with confusion, agitation, tachypnea and cyanosis. She offered no significant medical history. Her calculated BMI was 21 m²/kg. Diagnosed with a pulmonary embolism, tPA (50mg) was intravenously infused. Manifesting maternal shock and with a category III fetal heart rate pattern displayed on the electronic fetal heart rate monitor, she underwent abdominal delivery. In the immediate postpartum period, she was transferred to UMMC for veno-arterial ECMO. During cannulation of the right femoral artery, she lapsed into cardiac arrest. ACLS was initiated and ROSC was noted ten minutes later. A hysterectomy was performed for massive vaginal hemorrhage. Further abdominal exploration revealed liver injury including a ruptured subcapsular hematoma and a large infra-lobar (right) laceration. Echocardiography revealed a large left ventricular thrombus. Resuscitation, including hepatic artery embolization, was continued but unsuccessful and the patient expired the same day.

**Case 3**

A 24-year-old G3P2 presented to an OSH at 40 weeks’ gestation in active labor. She had a history of uterine fibroids. Her calculated BMI was 28 m²/kg. She underwent vacuum-assisted vaginal delivery. Subsequent massive (vaginal) haemorrhage, with clinical and laboratory signs of coagulopathy, led to hysterectomy. In the ICU, she suffered cardiac arrest. ACLS was performed; ROSC occurred. With continued clinical/laboratory signs of abdominal hemorrhage, the patient returned to the OR. Laparotomy revealed hepatic injury including a large linear infra-lobar (right) laceration and a large subcapsular hematoma of the dome. She remained
haemodynamically unstable even after embolization of the distal right hepatic artery. She was transferred to UMMC. She was stabilized and her coagulopathy corrected. Damage-control exploration of her abdomen was performed followed ten days later by a delayed primary closure. The patient recovered and continues to do well.

Discussion

Added to the normally tumultuous scene occurring at any cardiac arrest, having a pregnant patient who requires CPR heightens anxiety for all healthcare providers involved. Furthermore, the scenario can become more complicated if they must prepare for a perimortem caesarean section (PMCS) if there is no return of spontaneous circulation within an ideal goal of four minutes.8-11,13-15

The rate of CPR in the peripartum population of developed countries varies, including: The Netherlands (0.0019%); Scotland (0.002%); United Kingdom (0.0028-0.0063%); Canada (0.008%); and, the United States (0.085%).1 A study of maternal cardiac arrest in a Canadian tertiary care center reported a rate of 1:24,883 (0.004%), but excluded postpartum circulatory arrests.23

The peripartum CPR rate seen at our institution is almost 15-fold (0.12% vs. 0.0085%) higher as compared to published rates.1 A factor likely skewing our results is that as a tertiary care referral center, many of our obstetric patients are transferred from other hospitals where they have already been diagnosed with significant complications of pregnancy. This is in addition to our hospitals’ own high-acuity, high-risk obstetric patient population. Indeed, five of the 11 patients in this report were transferred to our facility (Table 1).

Liver injury after CPR in peripartum patients has not been well-studied.24,25 We could not find any comparisons of injury rates between women in the peripartum period undergoing CPR and those reported in the general population. Among the general population, reports on complications associated with CPR reveal the majority of complications are non-life threatening (e.g., rib fractures), while more severe complications (e.g., liver injury) are rare. In 1987, Krischer, et al., found the incidence of liver rupture to be 2.1%, in addition to “other liver injuries” at 0.8%, putting the total incidence of liver injury at 2.9%.17 A more recent study put
the overall rate at 0.6%, with an even lower rate of 0.5% in women. Published case reports of liver injury after CPR indicate that the complication was typically significant, resulting in hemorrhage and death. Two other case reports are reported of liver injury during CPR in pregnancy. Outside of pregnancy, a few case reports have purposed the reasoning for clinically significant liver injury is secondary to coagulopathy or untrained personnel. Our rate of clinically significant liver injury associated with CPR in pregnancy (27%) is likewise much higher than the published rates of liver laceration associated with CPR in the general population (0.6-2.1%). Two of the three patients were coagulopathic prior to arrest and this may have played a significant role in the mechanism of injury to the liver.

We can proffer an explanation for this increased rate of liver injury associated with CPR, partially due to the physiologic changes in pregnancy. One study found no significant rostral displacement of the heart in pregnancy; challenging the dogma of pregnancy-associated elevation of the diaphragm. This suggests the diaphragm acts as a “rigid wall” enclosing the abdominal organs. An enlarged uterus during pregnancy and even in the postpartum period results in less abdominal capacity and possibly physiologic compression of the liver capsule. In addition, increased intravascular volume and hepatic congestion as noted by other authors could potentially increase hepatic susceptibility to injury. More work, however, is needed to confirm this increased incidence of clinically important liver lacerations in peripartum patients, and to evaluate possible etiologies for this difference.

The major limitation of this study is that it is a retrospective case series of a rare event at a single institution. Additionally, we are unable to determine whether the rate of liver injury after CPR is specific to our high-acuity hospital as we did not calculate the period prevalence in non-pregnant patients. The survival to discharge rates for all patients receiving CPR at our institution is 25.0% which is similar to the findings of our study. A recent study, however, demonstrates that CPR in pregnancy has a better prognosis than non-pregnant individuals. Due to the limitations of record review, we were often unable to find details of the CPR performed, including hand position during closed chest massage or if any bedside alterations were made to resuscitation methods promulgated in the AHA guidelines for peripartum CPR. We were unable to account for confounding variables associated with coagulopathy in critically-ill gravidae, such as Thrombotic Thrombocytopenia Purpura (TTP), Disseminated Intravascular Coagulation.
DIC), or pre-eclampsia. All three patients who suffered liver lacerations developed DIC, two
prior to CPR and the other after successful resuscitation.

More accurate rates of both peripartum CPR and associated liver lacerations could be
revealed in a future study including data from multiple states- or nation-wide hospitals as well as
for a period longer than six years. This would allow for comparison of rates in age-matched
and non-pregnant women. If there is a pre-disposition to liver laceration in pregnant women then
nation-wide results might validate or support change in current guidelines for CPR in peripartum
women. Thought should be given to performing either surgical exploration, abdominal
ultrasound to evaluate for intra-abdominal free fluid, or CT evaluation of the upper abdomen in
all gravidae who remain haemodynamically unstable after cardiopulmonary resuscitation. A
shorter time-to-diagnosis of liver injury might increase the efficacy of available surgical and
non-surgical interventions to prevent complications of massive haemorrhage, transfusion and
shock.

Conclusions

Based on this small retrospective case series at our tertiary care, obstetric and trauma
referral hospital, liver lacerations requiring intervention occurred in 43% of gravidae patients
who survived CPR, and is significantly higher than published rates (0.6-2.1%) for the general
patient population. Further studies are indicated to determine if this rate of liver injury associated
with peripartum CPR is generalizable beyond our hospital. We believe that recognition of its
increased prevalence, and early consideration for the diagnosis allows for rapid treatment of this
life threatening complication, and may allow for an improvement in outcomes for these
unfortunate patients.

Conflicts of interest: None.

Individual Contributions of the Authors:

Timothy Cox: Conceived, primarily researched and prepared data, wrote and edited the final
manuscript.
Sarah Crimmins: Primarily conceived, wrote and edited the final manuscript

Allison Shannon: Researched and edited the final manuscript

Kristin Atkins: Conceived and edited the final manuscript

Ronald Tesoriero: Facilitated research and edited the final manuscript

Andrew Malinow: Facilitated research, wrote and edited the final manuscript

References


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**Table legends:**

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Methods: We identified pregnancies complicated by cardiac arrest by performing a retrospective medical record review from 2011-2016 at a single tertiary referral hospital. We then compared the rate of liver lacerations in this group to the rate in the general population as found in the literature.

Results: Eleven of 9408 women in the peripartum period suffered cardiac arrest. Return of spontaneous circulation occurred in seven of eleven (64%) women. Three of these seven women suffered clinically significant liver laceration (43%). Overall mortality rate among women suffering cardiac arrest was 82% (9/11). Even after return of spontaneous circulation, the mortality rate was 72% (5/7) including two of three women suffering liver laceration.

Conclusions: Based on a small retrospective study, liver lacerations requiring intervention occurred in 43% of gravidas patients that survived CPR, and is significantly higher than published rates (0.6-2.1%) for the general patient population. Further studies are indicated to determine if this rate of liver injury associated with peripartum CPR. Liver laceration more frequently afflicts women in the peripartum period who suffer cardiac arrest and receive CPR than what is reported in the general population. Liver laceration contributes to an overall poor outcome after cardiac arrest, even after successful return of spontaneous circulation.
Introduction

Maternal cardiac arrest is a rare, frightening and devastating event, often resulting in the demise of the mother, fetus/neonate or both. The most common cause of maternal cardiac arrest is haemorrhage, accounting for up to 40% of all cases.\textsuperscript{1-3} The reported rate of CPR among the peripartum population within developed countries ranges from 1:53,260 (0.019%) to 1:11,749 (0.0085%).\textsuperscript{1-5}

Cardiopulmonary resuscitation (CPR) is an important intervention that has improved survival after cardiac arrest since being described almost 60 years ago.\textsuperscript{6} Due to the physiologic changes that occur in pregnancy, guidelines for BLS/ACLS in the pregnant patient have been modified; for example, closed chest compressions are performed while manually displacing the gravid uterus to the left to alleviate compression of the vena cava and chest compressions are focused slightly higher on the sternum. However, exact hand placement is not specified and it is unknown if most responders are aware of this alteration.\textsuperscript{7-12} In addition, in the absence of a return of spontaneous circulation (ROSC) within four minutes, immediate perimortem cesarean delivery (ameliorating caval compression) is indicated to achieve optimal maternal outcome.\textsuperscript{4,7,11,13-15}

Though the liver is often congested due to a lack of venous return during cardiac arrest, the rate of liver injury in the general population after CPR is low.\textsuperscript{16-18} In pregnancy, hepatic congestion in addition to other physiologic changes are reported.\textsuperscript{7,19-22} While an enlarged liver in pregnancy is only reported in patient with prior liver disease\textsuperscript{19,20}, a more palpable liver immediately postpartum has been reported\textsuperscript{22}.

We hypothesized that chest compressions performed on pregnant and “early postpartum” patients are associated with an increased rate of liver lacerations during CPR as compared to the general population. Our primary objective was to determine the rate of liver laceration as a complication of CPR in pregnancy.

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The total number of peripartum women with cardiac arrest who receive CPR was divided by the total number of deliveries at UMMC from 2011-2016 to determine the period prevalence of CPR in pregnancy. The number of women with liver injury associated with CPR in pregnancy was divided by the previously determined total number of pregnancies complicated by cardiac arrest and CPR to determine the period prevalence of liver injury associated with CPR in pregnancy. A thorough literature review was performed to identify the rates of CPR as well as any published rates of liver injury from CPR both in the general population and in pregnant women.

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haemodynamically unstable even after embolization of the distal right hepatic artery. She was transferred to UMMC. She was stabilized and her coagulopathy corrected. Damage-control exploration of her abdomen was performed followed ten days later by a delayed primary closure. The patient recovered and continues to do well.

**Discussion**

Added to the normally tumultuous scene occurring at any cardiac arrest, having a pregnant patient who requires CPR heightens anxiety for all healthcare providers involved. Furthermore, the scenario can become more complicated if they must prepare for a perimortem caesarean section (PMCS) if there is no return of spontaneous circulation within an ideal goal of four minutes. 8-11,13-15

The rate of CPR in the peripartum population of developed countries varies, including: The Netherlands (0.0019%); Scotland (0.002%); United Kingdom (0.0028-0.0063%); Canada (0.008%); and, the United States (0.085%). † A study of maternal cardiac arrest in a Canadian tertiary care center reported a rate of 1:24,883 (0.004%), but excluded postpartum circulatory arrests. 23

The peripartum CPR rate seen at our institution is almost 15-fold (0.12% vs. 0.0085%) higher as compared to published rates. † A factor likely skewing our results is that as a tertiary care referral center, many of our obstetric patients are transferred from other hospitals where they have already been diagnosed with significant complications of pregnancy. This is in addition to our hospitals’ own high-acuity, high-risk obstetric patient population. Indeed, five of the 11 patients in this report were transferred to our facility (Table 1).

Liver injury after CPR in peripartum patients has not been well-studied. 24,25 We could not find any comparisons of injury rates between women in the peripartum period undergoing CPR and those reported in the general population. Among the general population, reports on complications associated with CPR reveal the majority of complications are non-life threatening (e.g., rib fractures), while more severe complications (e.g., liver injury) are rare. In 1987, Krischer, et al., found the incidence of liver rupture to be 2.1%, in addition to “other liver injuries” at 0.8%, putting the total incidence of liver injury at 2.9%. 17 A more recent study put
the overall rate at 0.6%, with an even lower rate of 0.5% in women.\textsuperscript{16} Published case reports of liver injury after CPR indicate that the complication was typically significant, resulting in hemorrhage and death.\textsuperscript{18,26,27} Two other case reports are reported of liver injury during CPR in pregnancy.\textsuperscript{21,28} Outside of pregnancy, a few case reports have purposed the reasoning for clinically significant liver injury is secondary to coagulopathy.\textsuperscript{16,27,29,30,31} Our rate of clinically significant liver injury associated with CPR in pregnancy (27\%) is likewise much higher than the published rates of liver laceration associated with CPR in the general population (0.6-2.1\%). Two of the three patients were coagulopathic prior to arrest and this may have played a significant role in the mechanism of injury to the liver.

We can proffer an explanation for this increased rate of liver injury associated with CPR, partially due to the physiologic changes in pregnancy. One study found no significant rostral displacement of the heart in pregnancy; challenging the dogma of pregnancy-associated elevation of the diaphragm.\textsuperscript{32} This suggests the diaphragm acts as a “rigid wall” enclosing the abdominal organs. An enlarged uterus during pregnancy and even in the postpartum period results in less abdominal capacity and possibly physiologic compression of the liver capsule. In addition, increased intravascular volume and hepatic congestion as noted by other authors\textsuperscript{7,20,22,33,34} could potentially increase hepatic susceptibility to injury. More work, however, is needed to confirm this increased incidence of clinically important liver lacerations in peripartum patients, and to evaluate possible etiologies for this difference.

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Conflicts of interest: None.

Individual Contributions of the Authors:

Timothy Cox: Conceived, primarily researched and prepared data, wrote and edited the final manuscript.
Sarah Crimmins: Primarily conceived, wrote and edited the final manuscript

Allison Shannon: Researched and edited the final manuscript

Kristin Atkins: Conceived and edited the final manuscript

Ronald Tesoriero: Facilitated research and edited the final manuscript

Andrew Malinow: Facilitated research, wrote and edited the final manuscript

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Table legends:

Table 1. Eleven women at a single tertiary referral center with cardiac arrest and CPR performed during the peripartum period.
ROSC=return of spontaneous circulation, C/S=caesarean section, TTP=thrombotic thrombocytopenic purpura, HUS=hemolytic uremic syndrome, DIC=disseminated intravascular coagulation, PE=pulmonary embolism, GDM=gestational diabetes mellitus, CKD=chronic kidney disease, ECMO=extracorporeal membrane oxygenation

Table 2. Three women who experienced liver injury after peripartum CPR.
<table>
<thead>
<tr>
<th>Pt</th>
<th>Age</th>
<th>Race</th>
<th>BMI</th>
<th>Comorbidities</th>
<th>Acute condition precipitating CPR</th>
<th>Gestational age</th>
<th>Delivery</th>
<th>Timing of arrest</th>
<th>Location of arrest</th>
<th>Length of CPR (minutes)</th>
<th>ROSC</th>
<th>Liver injury</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
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<td>25</td>
<td>T1DM, HTN, CKD</td>
<td>Pre-eclampsia, respiratory arrest</td>
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<td>C/S</td>
<td>Immediately</td>
<td>In-hospital, OB OR</td>
<td>15</td>
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<td>Yes</td>
<td>Died next day</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
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<td>21</td>
<td>None</td>
<td>(Transfer) Suspected PE</td>
<td>38-0</td>
<td>C/S</td>
<td>Day of delivery</td>
<td>In-hospital, CCRU during ECMO can OSH - ICU</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>Died same day</td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>AA</td>
<td>29</td>
<td>Fibroids</td>
<td>(Transfer) Haemorrhage</td>
<td>40-0</td>
<td>Vacuum-assisted</td>
<td>Day of delivery</td>
<td>In-hospital, OB OR</td>
<td>15</td>
<td>Yes</td>
<td>No</td>
<td>Alive</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>AA</td>
<td>55</td>
<td>GDM, morbid obesity</td>
<td>Haemorrhage</td>
<td>36-1</td>
<td>C/S</td>
<td>Day of delivery</td>
<td>In-hospital – L&amp;D RN</td>
<td>15</td>
<td>Yes</td>
<td>No</td>
<td>Alive</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>W</td>
<td>42</td>
<td>TTP, bipolar</td>
<td>TTP-HUS</td>
<td>32-6</td>
<td>C/S</td>
<td>32-6 weeks gestation</td>
<td>In-hospital - MICU</td>
<td>79</td>
<td>No</td>
<td>No</td>
<td>Died at time of arrest</td>
</tr>
<tr>
<td>6</td>
<td>38</td>
<td>W</td>
<td>48</td>
<td>GDM, obesity, HTN, B-cell ALL, eclampsia in prior pregnancy, pernicious anemia</td>
<td>-</td>
<td>Post-partum, delivered at 29-5</td>
<td>C/S</td>
<td>Day of Delivery</td>
<td>In-hospital – Cancer center</td>
<td>18</td>
<td>Yes</td>
<td>No</td>
<td>Died next day</td>
</tr>
<tr>
<td>7</td>
<td>26</td>
<td>W</td>
<td>26</td>
<td>Unknown. s/p MVC</td>
<td>(Transfer) Arrest s/p MVC</td>
<td>22-5</td>
<td>Vaginal</td>
<td>22-5 weeks gestation</td>
<td>On scene, EMS</td>
<td>-</td>
<td>Yes</td>
<td>No</td>
<td>Died 3 days after</td>
</tr>
<tr>
<td>8</td>
<td>27</td>
<td>W</td>
<td>25</td>
<td>Hypothyroidism</td>
<td>(Transfer) Peritonitis &amp; shock</td>
<td>Postpartum, delivered at 40-0</td>
<td>Vaginal</td>
<td>8 days postpartum</td>
<td>Trauma OR</td>
<td>45</td>
<td>No</td>
<td>No</td>
<td>Died at time of arrest</td>
</tr>
<tr>
<td>9</td>
<td>29</td>
<td>AA</td>
<td>25</td>
<td>None</td>
<td>(Transfer) DIC, PE</td>
<td>38-2</td>
<td>C/S</td>
<td>Postpartum (1 day)</td>
<td>OSH PACU</td>
<td>2</td>
<td>Yes</td>
<td>No</td>
<td>Died 2 days after</td>
</tr>
<tr>
<td>10</td>
<td>39</td>
<td>AA</td>
<td>33</td>
<td>GDM, HTN, Hep C, IVDA</td>
<td>Ascending aortic dissection w/ haemopericardium</td>
<td>33-3</td>
<td>C/S</td>
<td>Postpartum (1 day)</td>
<td>In-hospital, MICU</td>
<td>16</td>
<td>No</td>
<td>No</td>
<td>Died at time of arrest</td>
</tr>
<tr>
<td>11</td>
<td>33</td>
<td>AA</td>
<td>26</td>
<td>Pre-eclampsia</td>
<td>HELLP syndrome, DIC, shock</td>
<td>39-4</td>
<td>C/S</td>
<td>Day of Delivery</td>
<td>Trauma OR</td>
<td>30</td>
<td>No</td>
<td>No</td>
<td>Died at time of arrest</td>
</tr>
</tbody>
</table>

Table 1. Eleven women at a single tertiary referral center with cardiac arrest and CPR performed during the peripartum period. 
ROSC=return of spontaneous circulation, C/S=caesarean section, TTP=thrombotic thrombocytopenic purpura, HUS=hemolytic uremic syndrome, DIC=disseminated intravascular coagulation, PE=pulmonary embolism, GDM=gestational diabetes mellitus, CKD=chronic kidney disease, ECMO=extracorporeal membrane oxygenation.
<table>
<thead>
<tr>
<th>Pt</th>
<th>Gestational age</th>
<th>Complications</th>
<th>Hysterectomy</th>
<th>Timing of arrest</th>
<th>Length of CPR (minutes)</th>
<th>ROS C</th>
<th>Liver injury from CPR</th>
<th>Complications post-resuscitation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31-0</td>
<td>Eclampsia, respiratory arrest,</td>
<td>Yes</td>
<td>During delivery</td>
<td>15</td>
<td>Yes</td>
<td>R &amp; L Liver lacerations</td>
<td>Haemorrhage, DIC</td>
<td>Died day after CPR</td>
</tr>
<tr>
<td>2</td>
<td>32-0</td>
<td>Suspected PE, Thrombolytics</td>
<td>Yes</td>
<td>Day of Delivery</td>
<td>10</td>
<td>Yes</td>
<td>2 R Liver lacerations</td>
<td>Haemorrhage, DIC</td>
<td>Died same day as CPR</td>
</tr>
<tr>
<td>3</td>
<td>40-0</td>
<td>Haemorrhage, DIC</td>
<td>Yes</td>
<td>Day of delivery</td>
<td>-</td>
<td>Yes</td>
<td>R Liver laceration</td>
<td>DIC</td>
<td>Alive</td>
</tr>
</tbody>
</table>

Table 2. Three women who experienced liver injury after peripartum CPR.
AUTHOR DECLARATION /Conflict of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Manuscript: Liver lacerations as a complication of CPR during pregnancy

Sincerely,

Timothy R Cox, MSIV ___________________ Date 7/24/19

Sarah Crimmins, DO ___________________ Date 7/24/19

Allison Shannon, MD ___________________ Date __________________

Kristin L Atkins, MD ___________________ Date __________________

Ronald Tesoriero, MD ___________________ Date __________________

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