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Article type : Case Report

**Commotio cordis: A case report of a fatal blow**

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This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/1556-4029.14878](https://doi.org/10.1111/1556-4029.14878)

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## **Abstract**

Comotio cordis secondary to a blunt blow to the chest wall can result in ventricular fibrillation and sudden death in children. While it is commonly reported in adolescents during sporting activities, it may result from non-accidental trauma especially in infants and younger children. We report a case of a 6-month-old infant who presented to the Emergency Department in cardiac arrest. The patient's hospital records, postmortem imaging, and the autopsy results were reviewed. External Examination of the infant did not reveal any evidence of trauma. Postmortem imaging revealed multiple healing posterior rib fractures and a metaphyseal corner fracture, both considered fractures highly specific for physical abuse. The autopsy revealed a structurally normal heart with no microscopic abnormalities. The infant's father confessed to hitting the child on the chest after which the child became unresponsive. Given the constellation of postmortem imaging and autopsy findings in addition to the father's confession, the child's death was ruled as a homicide secondary to commotio cordis. Since there are no structural and microscopic abnormalities in the heart autopsy in cases of commotio cordis, timely on-scene investigation and a thorough investigation regarding the mechanism of injury are required to make this diagnosis. Early identification of non-accidental trauma is crucial and can prevent further abuse in other siblings.

## **KEYWORDS**

commotio cordis, child abuse, homicide, infant death, forensic pathology, autopsy, nonaccidental injury, physical abuse

## **Highlights**

- Commotio cordis secondary to an intentional blow to the chest can cause sudden death in younger children.

- Physical evidence of external trauma may be lacking, and the heart is normal structurally and microscopically in autopsy
- A high index of suspicion, thorough investigation, autopsy examination and caregiver interview are essential to confirm diagnosis.

## **Introduction**

A 6-month-old infant boy was transferred to the emergency department (ED) via Emergency Medical Services in cardiac arrest. His mother reported he vomited twice the day prior. The infant had otherwise been healthy and had a good appetite. He had no history of fever, diarrhea, seizures, or change in level of consciousness. He was a full term infant with no complications and had no previous illnesses or hospitalizations. The mother was very distraught and unable to provide a full history in the ED. She said the infant was being cared for by his father at the father's home. The father called the ambulance and she met them at the hospital.

On physical examination upon arrival, he had no vital signs and the pupils were fixed and dilated. There were no visible external signs of trauma. He was pronounced dead in the ED.

Due to the sudden unexplained death in the infant, a postmortem skeletal survey was performed. It showed 6 healing posterior rib fractures, 4 healing lateral rib fractures, and linear lucencies seen within 3 posterior ribs consistent with fractures of a more acute nature. He also had a suspected metaphyseal corner fracture of the right proximal femoral metaphysis.

When interviewed by the police, the father stated that he was agitated with the infant's crying and punched him in the back twice with his fist. When the infant wouldn't stop crying, his father hit him four or five more times on his chest. After he was hit the last time, the infant's body "froze up". His father could feel the infant's body "shut down" and heard him "gasping for air". There was no history of seizures or change in level of consciousness prior to the last blow to the chest. The father admitted to hitting the infant in the chest with a closed fist on previous occasions, trying to "toughen him up".

Autopsy revealed that the infant had two bruises on the right lower back, multiple calluses of the posterior and lateral right and left ribs and an acute fracture of the posterior right ninth rib with adjacent intercostal muscle hemorrhage. These corresponded to the radiologic findings. A callus was also noted on the lumbar vertebra (L5) anteriorly. There was no injury to the head or scalp hemorrhage and the brain had a normal gross appearance. The brain was further examined by a neuropathologist and appeared histologically normal. There were no yellow-brown discolorations of the dura or cortex. There were no fluid collections. Autopsy studies including detailed microscopic examination of the myocardium, conduction system and coronary arteries were negative for any structural injury to the heart. The foramen ovale was probe patent. There was no myocyte disarray, no endocardial fibrosis, and no fatty infiltration of the right ventricle. There was no known family history of any genetic cardiac anomalies and thus no indication for genetic testing. In consideration of the autopsy findings, postmortem imaging findings and the circumstances surrounding the infant's death, the manner of death was classified as homicide with the cause of death being commotio cordis.

The jury convicted the father of first-degree felony murder, and first-degree child abuse. He was sentenced to life in prison for felony-murder and eight to twelve years' imprisonment for first-degree child abuse.

## **Discussion**

Comotio cordis is a rare cause of sudden death secondary to a blunt direct blow to the precordium resulting in disruption of electrical activity in a structurally normal heart without visible or chemical injury to heart [1]. The two primary determinants of ventricular fibrillation and mortality associated with commotio cordis are (1) location of the blow directly over the precordium at or near the center of location of the heart and (2) timing of the blow during the 10-20 msec window of the electrically vulnerable period of the cardiac cycle during the upstroke of the T wave resulting in ventricular fibrillation [2]. In porcine models, precordial blows outside of this critical time period resulted in transient complete heart block, left bundle branch block or ST elevation rather than ventricular fibrillation. If the blow occurred during the peak of QRS complex of ventricular depolarization, it resulted in asystole and ST elevation. The sudden blow leading to commotio cordis is believed to cause a dramatic increase in left ventricular intracavitary pressure resulting in increased stretching of cell membranes and activation of ion channels. This in turn leads to an increase in transmembrane current flow predisposing to arrhythmogenicity [2].

The impacts resulting in commotio cordis are typically of low energy and low impact. It is postulated that high energy projectiles result in structural damage to the heart causing cardiac contusion and myocardial rupture rather than commotio cordis. Commotio cordis is more common among males and in those  $\leq 18$  years of age [3]. Children and adolescents are more vulnerable to commotio cordis secondary to their thinner musculature and compliant chest wall. Further, chest blows are more common in children than in adults. Though the majority of commotio cordis events are associated with accidental injuries sustained during organized or recreational sporting activities such as baseball, hockey and lacrosse, one fourth of events, can occur unrelated to sports and can be secondary to intentional blows to the chest as reported in our patient [2]. The outcome of commotio cordis is poor with only 15% of patients surviving their event [3]. Prompt cardiopulmonary resuscitation and defibrillation are the two important factors that determine survival from the event.

There have been four previous reported cases of commotio cordis secondary to non-accidental trauma in infants and children [4-7]. All reported cases occurred in children less than 3 years of age with the youngest case reported in a 7 week old [7]. These children did not have any external evidence of inflicted trauma other than patterned chest wall contusion (secondary to being hit with a knuckle) reported in one patient [5]. Toxicologic studies and skeletal surveys were all reported negative except for one patient who had rib fractures suggestive of non accidental trauma. In our patient, the skeletal survey showed healing posterior rib fractures consistent with non-accidental trauma. The presence of these fractures that are considered highly suspicious for child abuse and the absence of initial history added to the suspicion of child abuse in this case [8].

The diagnosis of commotio cordis secondary to non accidental trauma is usually based on caregiver's account of injury, clinical presentation of the child and a normal gross and microscopic anatomy of the heart noted at autopsy.

In all cases of sudden infant death, ancillary laboratory, imaging studies including skeletal survey and a thorough autopsy should be performed for not only documenting the presence of other injuries suggestive of non-accidental trauma but ruling out other medical causes that can result in sudden unexpected death in children [9]. In addition a thorough scene investigation, and interview of the caregivers regarding the events leading up to the collapse of the child may be helpful in leading to the diagnosis. Our case report highlights commotio cordis secondary to non-accidental trauma which is a rare but a reported cause of sudden unexpected death in younger children. It also highlights the importance of obtaining postmortem imaging which may show evidence of acute or chronic trauma as a result of child abuse. Even in the absence of an initial history as in our case, the skeletal survey findings may suggest child abuse. Lastly our case highlights the importance of a thorough investigation. Despite the absent history on presentation, the detectives investigating this case were able to obtain a detailed confession and narrative from the infant's father which was crucial in making the diagnosis.

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