Commotio Cordis: Introduction, Overview and Literature Review

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Abstract

Defined as a "blunt nonpenetrating trauma to the chest resulting in irregular heart rhythm and often leading to sudden death" [1], Commotio Cordis (CC) (also known as cardiac concussion [3]) is a topic that has intrigued the interest of many cardiologists, ED physicians, Sports physicians and scientists. Another lovely definition of CC is:

"Sudden cardiac death as a result of a seemingly innocent chest blow" [7]

Most impacts associated with CC occur in competitive sport settings, confrontations which evolve into violence and "recreational activities" are also another site where CC is possible [2]. We recommend the installment of protective measures in the manner described below. Numerous theories abound as to how and why CC occurs; these are discussed below.

In conclusion, we wish to inform first respondents, coaches (who regularly happen to be at the site of CC occurrence, emergency physicians and cardiologists of the possibility of the occurrence of CC in addition to how to manage such situations if they do abound.

Published by IJRP.ORG. Selection and/or peer-review under responsibility of International Journal of Research Publications (IJRP.ORG)

Keywords:

Cardiac concussion; Commotio Cordis; CC; Cardiac Death; Athlete; Review article; Sudden death

1. Main text

1. Introduction:

As aforementioned, CC is the result of a traumatic occurrence to the chest. CC usually manifests itself in the form of VF [1], sometimes CC manifests itself in the form of ventricular flutter, as present in the case report by Davey and colleagues [2].

Although still viewed as a relatively rare occurrence, reports discussing CC have been increasing throughout the years [1,4,5,6]. A particularly peculiar finding related to CC would be the maintenance of the structural integrity of cardiac tissue at autopsy [1], another remarkable notice would be related to the victims in the sense

that they are usually of a young age and are otherwise healthy [1].

In short, unless promptly addressed in the appropriate manner, CC is potentially a life-threatening scenario [1,2].

2. History and Epidemiology:

Some descriptions of CC go back as early as 1763 [1], however, the earliest descriptions of CC can be attributed to Giovanni Maria Lancisi (1654-1720), [8] a papal physician as well as a well-known author. In his book, "De Subitaneis Mortibus." (Chapter 10) ("Deficiencies of the heart and blood vessels that cause death in men very quickly,"), the following description can be found:

"I once saw the knot of life instantly
undone when a man received a powerful blow from a fist under the xiphoid cartilage." [8]

The above description is accepted by many to be the first ever documentation of Commotio Cordis. Shivkumar, in their article on the topic, said the following:

"Lancisi's description is worthy of being
referenced in this context as one of the earliest descriptions of this syndrome."[8]

which is in line with our above hypothesis.

In a more modern context, the first systematic evaluation (in so far as we have been able to determine) first took place back in 1932 by Schlomka and Schmitz [8]. Some argue that our current understanding of CC came to being following the famous 1999 paper by Maron et al. [9,10] A 2009 paper by Palacio and Link indicated that CC was a significant cause of sudden-death amongst young athletes [1]. In fact, according to the paper, CC was only second to hypertrophic cardiomyopathy [8], which is, by all means, a staggering statistic and is an indicative of immediate action towards increasing awareness of CC, how to prevent it and how to react once CC is suspected. Another cause of concern is that, according to the same paper, CC reports have been rising. We are unsure whether the increase is truly an increase of the incidence of CC or the result of better diagnostic procedures. As per our research efforts, no reliable data on CC is available on the Arab and African scientific literature. We do suspect an occurrence of CC in the Republic of the Sudan, however since we have yet to confirm the diagnosis, we have decided to not publish any details in relation to that case.

In the USA, the establishment of the 'US Commotio Cordis Registry' has resulted in easier obtaining of information related to CC.

A 2019 paper by Tainter and Hughes [11] discussed the CC phenomenon in intricate detail. In that paper, there is a discussion in regards to the epidemiology of CC. The discussion highlights the following points:

1) There is a negative correlation between age and occurrence of CC (i.e. older children and young adults are less likely to suffer from CC):

   The researchers hypothesize the causes for the finding to be either:
   a) In regards to the chest anatomy in children (i.e. children have thinner chest wall), which in turn increases the likelihood of CC manifesting in younger children, or
   b) An "increased likelihood to participate in activities where they are likely to be hit in the chest.", which is in relation to the exploratory nature of children.
2) A vast majority (95%) of CC cases are in males, which the authors hypothesize are the result of the aforementioned causes.

3) A difference in survival rates amongst children of different races. In particular, they found a staggering difference in the likelihood of survival between African Americans (4%) and whites (33%).

They hypothesized this to be the result of an increased likelihood of "delayed resuscitation (44% vs. 22%) and less frequent use of automated external defibrillators (AEDs) (4% vs. 8%).". [11]

It is also vital that we mention that, according to Palacio and Link [1], CC was most common among baseball players. The same study also noted that "Twenty-five
percent of reported cases of CC in youth baseball were from a pitch that averaged 30 to 50 mph" (~50-80 km/hr.).

3. Variables that play a major role in Commotio Cordis

A 2009 paper by Palacio and Link [1] as well as a 2003 paper by Link et. al. [12] illustrated the major variables associated with CC in an informative and concise manner, ergo, we have decided to summarize their findings, which were as follows:

1) The most common primary rhythm in CC is VF,
2) For CC to occur and result in VF, an impact must take place directly over the heart, plus the LV's center is the most vulnerable to such a manifestation.
3) Impacts to so-called "noncardiac sites" have not been found to cause VF.
4) Projectiles which are tougher in consistency are positively correlated with CC occurrence (i.e. softer projectiles are less likely to result in CC).
5) As aforementioned, for a projectile to result in VF, it has to be moving at speeds of 30-50 mph (~50-80 km/hr.). A report by Link et. al. concluded that "projectiles traveling 40 mph [(~60 km/hr.)] were most likely to cause VF in swine", an unexpected finding was that in which it was found that projectiles travelling at 50-60 mph (80-100 km/hr.) were actually less likely to cause VF [1,12].

In our estimation, the above methodology best summarizes the information related to the variables associated with CC.

4. Why does CC occur?

Whenever a dialogue discussing topics of great complexity is taking place, numerous theories abound in an attempt by those discussing the topic to arrive at a conclusion. CC partakes of the same essence. In an attempt to arrive at a proper understanding of CC, numerous dialogues/debates have taken place and, as a result, we have arrived at a number of theories as to how it occurs. In the upcoming paragraphs, we will be discussing these theories.

Numerous studies have illustrated that a quick increase in left ventricular pressure to 250-450 mmHg is likely associated with "electrophysiological consequences" [1]. It is also important that we know that stretch channels are likely stimulated as a response to a certain amount of myocardial stretch [1,12]. Another study found associated implications of the potassium adenosine triphosphate channel in terms of it being activated [1,14].

A theory that appears rather peculiar at first sight is the so-called "Critical mass theory" [1] which justifies the aforementioned proposition relating to the apparent juxtaposition with speed (velocity) of the projectile, the justification is, according to this theory, that projectiles moving at speeds of over 50 mph (~80 km/hr.) lead to damage of cardiac (myocardial) tissue, which result in contusion of the cardiac tissue as opposed to VF (i.e.: VF occurs in intact myocardial tissue). [1]

Another theory, which has been dismissed over a decade ago was built on our understanding of the human ANS, that theory suggested that the increased activity of CC was positively correlated with the occurrence of CC. As aforementioned, this theory was challenged by Stout and colleagues back in 2007[13] during which it failed to substantiate itself as a viable theory of the occurrence of CC. [1,13].

5. Diagnosis

Sudden cardiac death is seen in many diseases, which explains why a lot of cardiac diseases are included in the differential diagnosis like hypertrophic cardiomyopathy,
coronary artery abnormalities, arrhythmogenic right dilated cardiomyopathy, aortic valve stenosis, mitral valve prolapse, and coronary artery disease, etc. The most important factor in diagnosing CC after excluding the diseases mentioned above, is by an accurate history taking in which there is a witness of a trauma directly to the chest, increasing the likelihood of CC [1].

6. Prevention

"Prevention is always better than the cure."
The US Consumer Product Safety Divisions recommends soft "safety" baseballs to reduce the risk of soft tissue trauma [16], this, in our estimation, is negatively correlated with the occurrence of CC.
Using chest protectors during games could also help decrease the impact of the trauma, although during games it becomes malpositioned and doesn't completely cover the pericardium ergo decreasing its efficiency. This means that more research should be made on how to make chest protectors that completely cover the pericardium and remain in position during games to make it a more preventive and efficient technique [1].
Athletic equipments should always be evaluated and tested seriously as this can decrease all injuries and not just CC.

7. Treatment

Since CC usually occurs in outdoor settings, we have decided to address this critical division of the paper in the following fashion:

Facts associated with CC
Emergency Treatment (field, ambulance, etc.)

2 intriguing hypotheses associated with CC are:

1) Streptomycin (a calcium stretch-sensitive ion channel blocker), although did not reduce the occurrence rates of CC, was found to reduce ST elevation following impact [1].
2) Gilbenclamide was found to 1) reduce incidence of VF and 2) attenuate ST-segment elevation [1].

Upon witnessing a direct chest trauma early defibrillation is the life-saving technique, it's crucial to immediately start CPR and AED [1].
Although, it's worth mentioning that resuscitation after CC is usually unsuccessful [1].
The aforementioned techniques are to be used in the site of impact (most likely the playground) and require immediate interference.
Our observation has been that the vast majority of CC cases don't survive the impact and are deceased by the time they get to the hospital.
The 2010 American Association Guidelines has recommended the use of therapeutic hypothermia for adult patients that present with a cardiac arrest with a rhythm of ventricular fibrillation, this has treated a case of CC before [15].

8. Recommendations:

1) Bringing forth greater levels of awareness amongst vulnerable groups (e.g. young athletes in underprivileged regions of the world)
2) Research on the adherence of possible CC victims to protective clothing guidelines.
3) Research on the effectiveness of protective clothing and other equipment in reducing the likelihood of occurrence of CC.
4) Training of coaches on the diagnosis of CC.
5) Training of coaches on the performance of CPR and the use of defibrillators
6) The establishment of a national CC registry in every nation around the globe.
7) The establishment of an international CC registry to permit easier access to worldwide information related to CC.

9. Abbreviations:

CC = Commotio Cordis
ED = Emergency Department
VF = Ventricular Fibrillation
USA = United States of America
Mph = Miles Per Hour
Km/hr. = Kilometers Per Hour
LV = Left Ventricle
ANS = Autonomic Nervous System
CPR = Cardiopulmonary Resuscitation
AED = Automated External Defibrillator

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