



Death caused by cardioinhibitory reflex cardiac arrest—A systematic review of cases

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ABSTRACT

Forensic pathologists often refer to the cardioinhibitory reflex cardiac arrest (CiRCA) following short neck trauma as a mechanism of death. We sought via a systematic review of the literature to identify circumstances under which carotid bifurcation stimulation could lead to death. Two independent reviewers selected case studies or reports from Medline, ISI Web of Knowledge, and Embase. Circumstances and contributory factors were extracted for each case. From the available data, authors independently assessed whether CiRCA was highly probable (no alternative explanation possible), probable (alternative explanation possible), or unlikely (alternative explanation highly probable). A narrative approach was used to define circumstances in which CiRCA remained possible. From the 48 published cases evoking CiRCA as a possible cause of death between 1881 and 2009, 28 were most likely to result of other mechanism of death (i.e., cerebral hypoxia due to carotid compression, mechanical asphyxia, myocardial infarction). CiRCA remained possible for 20 cases (including five based on anecdotal evidence only) with only one case with no alternative explanation other than CiRCA. Our findings support the presumption that reflex cardiac arrhythmia due to carotid bifurcation stimulation cannot provoke death alone. Actual state of knowledge suggests CiRCA might be contributory to death in the presence of drug abuse and/or cardiac pathology, often associated with physical and/or mental excitation.

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1. Introduction

Parry in 1799, Waller in 1862, and Landois in 1865 were among the first authors to report that a compression of the side of the neck could lead to circulatory collapse [1]; however, they gave no pathophysiological explanation for the phenomenon. In 1868, Czermak [2] wrote that it was the result of direct excitation of the vagal nerve. Hering [3] in 1924 performed animal experiments and observed that compression of the neck influenced heart rate. He explained this observation by a mechanical stimulation of the carotid sinus, thus describing the arterial baroreflex. Franke [4] delineated in his papers different types of responses of the syndrome of the carotid sinus with important interindividual variations. The regulatory effect of carotid sinus stimulation is often used in cardiology for diagnosis [5] and therapy [6].

The evaluation of the dangers of neck compression without restriction of the arterial flow remains unresolved in forensic medical practice. It is generally accepted [7] that a blow or a short compression of the side of the neck stimulating the carotid sinus can lead to circulatory collapse resulting from activation of an arterial

baroreflex controlling the heart rate. This cardioinhibitory reflex cardiac arrest (CiRCA) has, however, not been observed in animal experimental settings [8]. In legal medicine, there is therefore a need to study the circumstances of death when CiRCA has been mentioned to understand the possible underlying mechanisms that could explain why and when such stimulation leads to death.

We performed a systematic review to identify published cases in which CiRCA was evoked as a possible mechanism of death. This observational study aimed to describe conditions in which CiRCA was thought to be possible and to review authors' conclusions in the light of current knowledge.

2. Materials and methods

2.1. Search strategy

Our search strategy included both published cases in biomedical journals and those published in textbooks. To retrieve cases from published articles, we used no restrictions for time or language. Many articles were expected to be indexed before the 1970s without an abstract. Our search strategy therefore had to include as many terms as possible that might be included in titles. To achieve an optimal balance between sensitivity and specificity, we used as many terms as feasible to restrict our search to articles that referred to death caused by a reflex following trauma to the neck (Box 1). Titles and abstracts, when available, were extracted from Medline, Embase (1974–current), and ISI Web of Knowledge on June 25, 2009. Duplicates were automatically discarded by the reference managing software (Endnote 2.0) at importation, and those that the software did not identify were manually discarded.

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Box 1. Search strategy**#1 Death**

death OR deaths OR die OR died OR decline OR declines OR declined OR mortal OR mortality OR life threatening OR life endangerment OR decease OR deceased OR perish OR perished OR arrest OR heart failure OR cardiac failure OR myocardial failure

#2 Reflex

sudden OR abrupt OR immediate OR short OR brief OR unexpected OR unexplained OR reflex OR reflexes OR baroreflex OR baroreflexes OR circulatory collapse OR Hering OR vasovagal OR vagal OR cardioinhibitory

#3 Trauma

violence OR violent OR trauma OR traumatic OR injury OR injured OR lesion OR strangulation OR strangulations OR compression OR pressure OR stimulation OR stimulations OR excitation OR choke OR choking

#4 Localization

neck OR throat OR gullet OR carotid OR carotids OR baroreceptor OR baroreceptors

#1 AND #2 AND #3 AND #4

To identify cases from textbooks, we manually searched references from articles and from identified textbooks. When possible, original reports of cases were explored. We then tracked cases back to their earliest published report. A librarian obtained copies of historical medical textbooks for us to use for reading and retrieving cases.

Finally, to identify cases eventually reported in the grey literature, we consulted experts for information about any known case that our search strategy did not identify. We used no language restriction and employed interpreters if texts were not written in English, French, German, or Italian.

2.2. Article selection

One author excluded all articles that did not in any way concern the neck or a compressive mechanism. Two reviewers then independently selected articles based on titles and abstracts. Articles were discarded if they did not concern humans and mechanical stimulation of the carotid sinus, if individuals survived, if death was clearly reported from a cause other than CiRCA, or if initial cardiac arrest was not sudden. From this first selection, the reviewers collected and read the full articles.

We then used the following criteria to select articles: They had to include at least one case in which a victim died, the death had to be related to a sudden neck trauma, and authors had to have mentioned CiRCA as a plausible cause of death. If reviewers had discordant views on these criteria, the study was retained for the next step, which involved achieving consensus after discussion with all current authors once both reviewers individually extracted the data.

2.3. Textbooks and non-indexed articles

References from each retained article were screened to detect cases from textbooks and non-indexed articles. The institution librarian retrieved the sources, which the authors then reviewed. In turn, references from textbooks and non-indexed articles were manually searched to find original descriptions of cited cases.

2.4. Data extraction

When the information was available, two reviewers extracted the following for each identified case and entered it into an Excel sheet: gender, age, profession, history of cardiovascular disease, history of substance abuse, sudden neck trauma, circumstances of trauma, sequence of events, presence of witnesses, duration of trauma, local neck lesions, other lesions or signs, cardiac and cerebral status, toxicological findings, and genetic investigations. In addition, when possible, original authors were contacted for further details when published descriptions of cases were unclear.

2.5. Synthesis

Three experienced experts in forensic medicine reviewed each case independently. They were asked to report their interpretation of possible likely mechanism of death related to the described neck trauma. Furthermore, for each case they had to report whether they thought CiRCA was highly probable (no alternative explanation possible), probable (alternative explanation possible), or unlikely (alternative explanation highly probable). Mechanism of death was defined as the succession of events that best explains the link between the initial cause (usually neck trauma) and death [9]. Cases for which the three reviewers did not all agree were discussed until a consensus was reached.

Description of victims' age, gender, and presence of local injury of the carotid bifurcation were recapitulated in another table. Contributory factors (history of cardiovascular disease, alcohol, drugs, acquired and congenital electrical cardiac abnormalities, excited delirium) were also reported when available. The restricted number of cases made it impossible to synthesize results using a meta-analysis. Alternatively, a narrative approach to interpret conditions that could favor CiRCA was used instead.

Table 1

Most probable mechanism of death for cases in which cardioinhibitory cardiac arrest was ruled out.

Id	Authors	Case	Age ≥ 50 y	Male	Carotid compression	Heart disease	Respiratory asphyxia	Vascular dilacerations	Anaphylactic shock	Autopsy	Anecdote
21	Gilbert 2008 [15]	–		x	x					x	
22	Kohli 1996 [10]	–			x					x	
23	Yamamoto 1994 [22]	–	x	x	x					x	
24	Opeskin 1992 [11]	–	?	x			x			x	
25	Sigrist 1989 [21]	2	x			x				x	
26	Sigrist 1989 [21]	3						x		x	
27	Sigrist 1989 [21]	7	x	x		x				x	
28	Denk 1988 [36]	1			x					x	
29	Denk 1988 [36]	2	x		x					x	
30	Kowai 1987 [38]	8		x	x					x	
31	Kowai 1987 [38]	10		x	x					x	
32	Reay 1982 [32]	1	x	x		x				x	
33	Kaiser 1967 [28]	–	?	x					x	x	x
34	Kaiser 1967 [28]	–		x	x					x	x
35	Kaiser 1967 [28]	–			x					x	x
36	Kaiser 1967 [28]	–	x							x	x
37	Olbrycht 1963 [31]	–		x	x				x		x
38	Bowden 1962 [24]	–			x						x
39	Giese 1930 [27]	–			x					x	
40	Dyrenfurth [26], Lochte [29] 1930	–			x					x	
41	Bogdan 1925 [23]	–			x					x	
42	Lösener 1908 [30]	–	?	x	x					x	x
43	Strassmann 1908 [34]	–	?		x					x	x
44	Strassmann 1908 [34]	–	?	x	x					x	x
45	Emmert 1900 [61]	–		x	x					x	
46	Brouardel 1895 [25]	–			x						x
47	Brouardel 1895 [25]	–	x				x				x
48	Maschka 1881 [63]	–		x			x			?	x
Total			7/23	14/28	18/28	3/28	3/28	1/28	2/28	22/27	12/28

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