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Review

Approach to cardiopulmonary resuscitation induced consciousness, an emergency medicine perspective

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ABSTRACT

Background: Cardiopulmonary resuscitation (CPR) remains the key intervention following cardiac arrest because of its ability to continue circulation. Recent focus on high quality compressions during CPR has coincided with more frequent encounters of CPR Induced Consciousness (CPRIC). CPRIC represents a poorly understood patient experience during CPR and defined as signs of consciousness and pain perception during CPR.
Methods: Articles were selected using PubMed, MEDLINE, CINAHL and Scopus search for the keywords "cardiopulmonary resuscitation", "consciousness", "awareness", "resuscitation", "cardio-cerebral resuscitation", "agitation" and "patient experience" yielding 336 articles. Results and their references were assessed for relevance. Articles were filtered by English language and the keyword. Case reports and case series were included. All remaining articles were reviewed and findings were discussed.
Results: A total of ten articles were selected, which included data on 123 cases. Sample size varied per study from 1 to 112. Studies included cases of out-of-hospital cardiac arrest and in hospital cardiac arrest. Compressions were manually provided in most cases. Patient total recall was reported in 40% of cases. Use of sedation was reported in 40% of cases.
Conclusions: There is need for continued research to better describe, explain and manage the phenomena of CPRIC. From the articles reviewed here, it is clear that further investigation has the potential to properly elucidate the patient experience including lasting psychological effects of CPRIC. Importantly, there is need for more than recognition of CPRIC from national authorities. Future research efforts should focus on establishing guidelines for the use of sedation and physical restraints, as well as the potential impact of treating CPRIC on survival.

1. Introduction

Cardiac arrest is a public health concern across the globe. In the United States, it is estimated that 500,000 cardiac arrests occur annually [1]. The majority of these, nearly 70%, occur outside the hospital. Survival rates for outside-of-hospital cardiac arrest (OHCA) vary widely, from 0 to 20.4% throughout North America. This significant variation in survival rate has been documented even when controlling for patient demographics, cardiac arrest characteristics and emergency medical services response. In-hospital cardiac arrests (IHCA) differ in this regard from OHCA. Patient demographics, such as age and sex, are associated with better survival rates from 10.8% up to 30 [2-4].

Cardiac arrest represents a significant source of mortality however swift initiation of cardiopulmonary resuscitation (CPR) offers potential reversibility [5]. This life-saving intervention employs chest compressions and ventilation to maintain a level of cardio-cerebral blood flow reducing anoxic cell damage until the interdependent functions of the heart, lungs and brain are restored with return of spontaneous circulation [6]. Since the first published guidelines in 1966, revisions and new recommendations have been put forth regularly to improve outcomes [7]. Limited progress in survival rates of both OHCA and IHCA has been achieved with changes to guidelines over the last decade [8-10]. These changes have emphasized minimal interruption in chest compression, chest compression quality in regards to depth and rate, awareness of overventilation and reduced leaning motion from care providers [11,12]. Even when CPR is performed according to guidelines, it has not been shown to replicate normal physiology. Compressions restore only 10–30% coronary blood flow and 30–40% cerebral blood flow [13].

Recently, cardio-cerebral resuscitation (CCR) has been introduced as a compression only response to cardiac arrest. This method is promising given return of spontaneous circulation and neurological outcomes are dependent on flow to brain brought about by compressions [14]. Although newer than CPR, equivalent survival rates have been observed with implementation of CCR for OHCAs witnessed by lay-rescuers [15]. Some studies have even shown improved survival and outcome benefits [16]. Continuous cerebral blood flow made possible by uninterrupted

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compressions may contribute to the improved neurological outcomes associated with CCR [17].

During this period of advancement in resuscitation science, reports of life-like behavior in pulseless patients receiving compressions have surfaced. Patients in cardiac arrest who are able to breath, speak, follow commands and make purposeful movements during resuscitation have been observed and consequently a growing number of these cases have been documented in the literature [18]. In a quest to better explain this phenomena, Olaussen et al. has defined CPR induced consciousness (CPRIC) as a display of at least one of the following behaviors: spontaneous eye opening, jaw tone, speech or body movement; in pulseless patients undergoing active CPR [18]. These cases have generated significant academic intrigue but largely remain unexplained. Aside from the physiologic mystery surrounding how these behaviors occur, behavior inconsistent with cardiac arrest in patients without a pulse creates a challenging situation for medical personnel. The return of spontaneous breathing, motor activity, awareness, consciousness and pain perception in the setting of cardiac arrest make return of spontaneous circulation more difficult to achieve as the patient can actively resist compression and disconnect airway devices.

For the patient, consciousness, awareness and pain make resuscitation efforts traumatic and introduce new potential for psychological harm. Survivors of cardiac arrest without CPRIC have reported differing degrees of psychological sequalae following successful resuscitation in the past. These experiences are often grouped together and described as Near-Death Experiences (NDE). Greyson et al. defines NDE as a profound psychological event with transcendental and mystical elements after a life-threatening crisis [19]. Awareness and recall of resuscitation events are rare themes among NDE reports in patients without CPRIC, however, it is possible that CPRIC patients may process the experience of resuscitation in similar manner. It is just as possible that CPRIC patients have a unique psychological experience of resuscitation but more cases specifically asking this question would be needed. The patient experience of CPRIC is far from understood, however, exploration of NDEs in cardiac arrest survivors may provide insight about the patient experience of CPRIC.

As high-quality resuscitation including CPR and CCR continues to be performed and refined, exploration of this rare phenomenon is required. Currently, there are no standardized guidelines for these behaviors and individual resuscitation teams must make decisions about restraints, analgesia and sedation based on judgment alone. Additionally, because so little is known about these occurrences, patients may not be fully aware of all of the potential risks of resuscitation when designating their own resuscitation status. One such risk may be psychological in nature as survivors of CPRIC may endure long lasting psychological sequalae.

This paper will review existing literature surrounding these unusual events from the perspective of the provider and from the patient in search of unifying themes and conditions that may direct future research efforts and inform forthcoming discussions.

2. Methods

PubMed, CINAHL, Scopus and MEDLINE databases were reviewed to assess the literature on CPR induced consciousness. The terms "resuscitation", "cardiopulmonary resuscitation", "consciousness", "cardio-cerebral resuscitation", "awareness", "agitation" and "patient experience" were used. The result revealed 336 matches. Search results were further limited to English language, human, full texts articles. Boolean operators and medical subject headings (MeSH) terms were used to combine search terms. All types of studies and designs, including case reports and case series, were considered for inclusion. The bibliographies of included studies were reviewed to provide supporting information. Data were extracted from each article, specifically the sample size, study setting, and design. Studies were excluded if they included patients under the age of 18, and did not specifically observe CPRIC during CPR. Selection Criteria is annotated in Fig. 1. Ten articles were found to be relevant (Table 1).

3. Results

3.1. The provider perspective: presentation and identification of patients with CPRIC

Ten articles including 4 OHCA, 6 IHCA were considered. Mechanical compression devices were used in 6 of the 10 cases. Care teams in 3 of the 10 CPRIC cases used sedation.

A retrospective study using registry data on OHCA was published by Olaussen et al. in 2017, examined the relationship with CPRIC and survival. They found that 0.7% of OHCA cases were associated with CPRIC. In patients with CPRIC following an unwitnessed or bystander witnessed cardiac arrest there were increased odds of survival to hospital discharge. However, odds of survival were not altered for patients with CPRIC following cardiac arrest witnessed by emergency medical service personnel. In their review of the documented CPRIC cases in this registry, 37.5% of CPRIC patients were given midazolam, opiates or muscle relaxant medication. The odds of surviving did not increase for CPRIC patients who presented as unwitnessed or bystander witnessed cardiac arrest and were given conscious altering medications (midazolam, opiates, muscle relaxants) [20].

In a cross-sectional study Olaussen et al. surveyed 100 healthcare professionals about their experiences with CPRIC. Responses were collected about events consisting of eye-opening, agonal breathing and mild restlessness termed CPR-induced non-interfering consciousness as well as events where withdrawing from CPR, purposeful movements and pulling at airway devices were observed termed CPR induced interfering consciousness. 59 out of 67 responding professionals reported experience with CPR Induced non-interfering consciousness. With respect to this defined subsect of CPRIC, the majority of cases were observed with chest compressions delivered by healthcare providers. Only 9.38% of cases were observed with mechanical compression devices. Of the healthcare providers surveyed in this cross-sectional study 70% of responders wanted to see guidelines for the management of CPRIC [21].

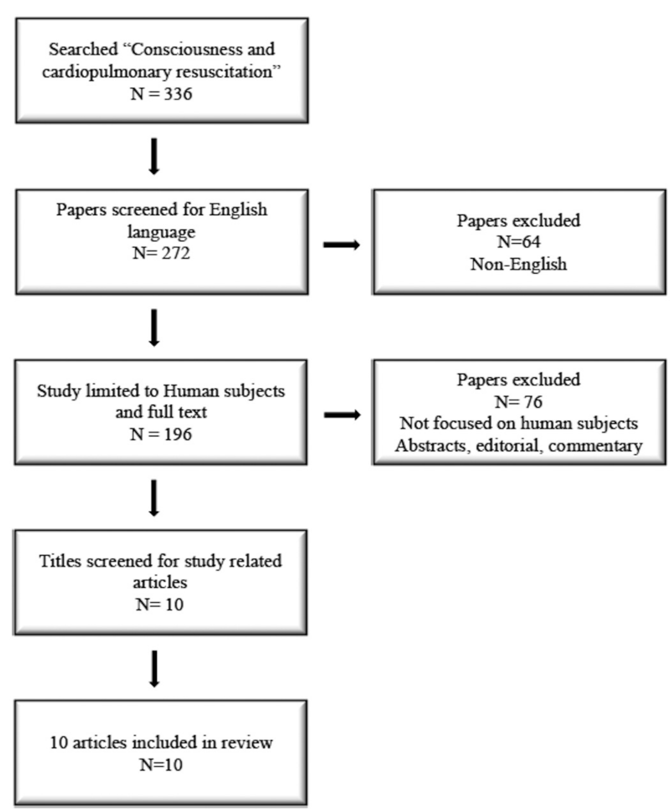

Fig. 1. Consort chart for search methodology.

Table 1
Case studies documenting CPR-induced consciousness (CPRIC).

Author	Case	No.	CCR	Sedation	Automated compression device	Total recall	Neurological consequences
Olaussen et al. [20]	Retrospective study of 16,558 patients with OHCA, identifying a 0.7% rate of CPRIC. CPRIC found to have an independent association with increased odds of survival to hospital discharge in non-EMS witnessed cardiac arrests (OR 2.09, 95% CI 1.14, 3.81; p-0.02)	112	No	[a]See footnotes	[b]See footnotes	n/a	n/a – not reported
Pound et al. [22]	52-year-old man with witnessed OHCA in vfib who made purposeful movements during resuscitation.	1	No	No	No	No	Good outcome
Wacht et al. [23]	57-year-old man with vfib following witnessed OHCA. Patient appeared made purposeful limb motion	1	Yes	Yes	Yes	Yes	n/a – not reported
Rice et al. [24]	55-year-old man developed vfib after OHCA. Patient was communicative and making purposeful movement during vfib.	1	No	Yes	Yes	Yes[c]	None
Bihari & Rajajee [25]	57-year-old ICU patient who developed bradycardia and asystole but made purposeful movements during CPR Physical restraints were used.	1	No	No	No	n/a	n/a – deceased
Hoppenfeld et al. [26]	51-year-old man who made purposeful movements and was able to breathe spontaneously while in vfib in PACU.	2	No	No	No	Yes	None
Tobin & Mihm [28]	62-year-old man with IHCA who continued to generate respiratory effort, move, and open eyes during compressions. Invasive blood pressure monitoring was available during resuscitation.	1	No	No	No[d]	No	n/a – deceased
Frédéric et al. [29]	57-year-old man who received automated chest compressions was observed opening eyes and made movements on command.	2	No	Yes	Yes	n/a	n/a – deceased
Gray [30]	38-year-old male who developed polymorphic vfib in the Emergency Department. Patient was observed pushing care provides, making purposeful movements, and verbalizing.	1	No	No	No	No	None

[a] 49.1% of cases were sedated.
[b] 4.5% of cases used mechanical compressions.
[c] Total recall of event before sedation was given.
[d] Care team planned to use mechanical compression device but the device was unable to provide effective compressions.

In a case of CPRIC published by Pound et al., a 52-year-old man had a witnessed OHCA. He was assessed and found to be in ventricular fibrillation (vfib) when paramedics arrived. Standard ALS protocol was initiated and he was defibrillated twice. The patient appeared agitated and engaged in purposeful limb movement. Sedation was not given. After 65 min of resuscitation, this man had return of spontaneous circulation. Following resuscitation, he was reported to have intact neurological function with a cerebral performance score of 1 [22].

Wacht et al. reported the case of a 57-year-old man who presented in vfib following a witnessed OHCA. Chest compression only resuscitation was started by a bystander until paramedics arrived and initiated CPR. After defibrillation, the patient began to receive compressions via a mechanical compression device. Providers treated the patient's combative behavior with midazolam. The patient reported full awareness of the resuscitation event [23].

Rice et al. described the case of a 55-year-old man who developed vfib following an inferior myocardial infarction. CPR was performed, the patient was defibrillated, and ROSC was obtained. Shortly after arriving to the hospital, he returned into vfib but continued to be communicative, awake, alert and moving purposefully. During the ensuing 23 min resuscitation, Ketamine was given for sedation purposes and the patient survived without neurological deficits [24].

Bihari and Rajajee discussed the case of a 57-year-old man admitted to the ICU who transitioned from bradycardia to asystole before CPR was initiated. He made purposeful movements with upper limbs and eyes in response to the stimulating events of CPR. No sedation was given however physical restraints were used. The patient did not survive [25].

Hoppenfeld et al. described their experience with 2 events of CPRIC. A 50-year-old man developed vfib in post-operatively and was observed making purposeful movements and breathing spontaneously during this time. The patient became unresponsive during pauses in compressions. The patient survived and reported full recollection of the resuscitation. An unconscious 51-year-old man was discovered to be in vfib in the post-anesthesia unit (PACU). After defibrillation the patient appeared to regain consciousness and continued to be responsive until return of spontaneous circulation. He interrupted compressions by attempting to push care team members away. This patient reports full recollection of the resuscitation [26].

Oksar and Turhanoglu shared the case of a 69-year-old man who went into vfib while in PACU. The patient exhibited defensive reflexes and was breathing spontaneously throughout CPR. This patient was found to have some metabolic imbalances including elevated lactate, low pH, low bases excess and hypokalemia. Spontaneous circulation was achieved after correction of these imbalances and the patient avoided all neurological consequences [27].

Tobin and Mihm described a 62-year-old man with IHCA who was observed making respiratory efforts during CPR. The patient was also seen opening his eyes and making purposeful movements. Sedation was not given because the patient was re-directable with verbal communication. This case of CPRIC stands out because invasive monitoring was available at the time of arrest. Authors report that the patient became unresponsive when mean arterial pressure was less than 50 mm Hg or the rate of compressions fell below 100 compressions per minute [28].

A case of CPRIC occurred in a 57-year-old man who was an OHCA. ACLS guidelines were followed and he received compressions from a mechanical device. This patient was seen opening and closing his eyes as well as moving his arms on command. In this situation, the care team opted for sedation. The patient did not survive [29].

Gray shared the case of a 38-year-old male with polymorphic vfib who lost consciousness with cardiac arrest before compressions were started. Once compression began, the patient was described as making purposeful movement, pushing resuscitation providers and speaking. The resuscitation providers did not use sedation or physical restraints in the case. This patient survived with full neurologic recovery. The patient did not recall the events of resuscitation aside from a description of chest discomfort and two shocks [30].

3.2. The patient perspective: does CPRIC require a change in management?

In a 2017 systemic review and meta-synthesis, Haydon et al. examined quality of life following CPR and discovered five qualitative themes in survivors of cardiac arrest [31]. The identified themes included, multitude of contrasting feelings, disruption in the continuum of time, new reality and psychological challenges, changed body with new limitation and confrontation with death.

Another systemic review assessed cognitive function following OHCA and CPR. Moulert et al. found that there is a wide range (6–100%) of in terms of reported prevalence of cognitive dysfunction in these patients.

Memory impairment was the most common form of cognitive dysfunction reported although deficits in attention and executive functioning were also noteworthy. The review withholds conclusions due to limited quality evidence. [32]

Quality of life and outcomes for survivors of cardiac arrest were assessed again as part of a 2017 integrative literature review. Haydon et al. concluded that cardiac arrests survivors mostly face an acceptable quality of life. In their review, they also note that some survivors encounter anxiety, depression, posttraumatic stress disorder and cognitive deficits. [33]

In a review of 2060 cardiac arrest cases, Parnia et al. interviewed 101 survivors about the experience of cardiac arrest and resuscitation [34]. Memories with overarching themes related to fear, animals, plants, bright light, violence, déjà vu and family as well as recall of events after cardiac arrest were reported in 46% of patients. A small group of patients (9%) recounted a NDE. One patient had a period of conscious awareness that was deemed accurate.

An earlier review by Parnia et al. concluded that patients who survive cardiac arrest may have some level of cognition occurring at the time of arrest and throughout the resuscitation and that a select number of these patients are able to correctly recall events of resuscitation during periods of CPRIC [35]. The authors suggested here that NDE may act as a psychological protective mechanism.

The incidence of NDE among cardiac arrest survivors was also found to be variable in a 2005 review by French et al. [36]. Although the reported incidence in this review ranges from 6.3% to 23% of cardiac arrest survivors, the authors conclude that the true incidence of NDE is likely between 10% and 12% of cardiac arrest survivors. This paper reviewed several theories – spiritual, psychological and organic pertaining to NDE as well as specifically examining NDE in cardiac arrest survivors. Included in this review were 4 prospective studies about NDE in cardiac arrest survivors. Van Lommel et al. interviewed 344 cardiac arrest survivors shortly after resuscitation [37]. They found that patients who had experienced their first myocardial infarction as well as patients 60 years-old or younger were more likely to acknowledge having a NDE. Patients with memory dysfunction following resuscitation were less likely to report NDE. In this study, a greater number of patients who reported a NDE died within 30 days of a cardiac event. The authors of this study interviewed surviving patients again 2 and 8 years after the initial cardiac arrest. These interviews confirmed that a NDE may affect patients far into the future. Additional evidence to support the idea that cardiac arrest survivors with NDE may experience long lasting psychological sequalae was provided by Schwaninger et al. [38]. In a prospective study by Greyson et al., a greater number of cardiac arrest patients reported NDE compared to patients admitted to the cardiac intensive care unit for other reasons [19]. Similar to Van Lommel et al.'s finding, they report a greater incidence of NDE among younger cardiac arrest survivors. Patients who endorsed paranormal thoughts before the time of cardiac arrest were more likely to report NDE following cardiac arrest.

Because of these experiences and the impact of NDE and potentially CPRIC, there are suggestions in the guidelines that patients should be sedated when CPRIC is discovered. The only guidelines identified by this review are the Dutch National Ambulance Guidelines and the State of Nebraska Model Protocol [39]. The Dutch guidelines recommend the use of fentanyl and midazolam while the Nebraska Model Protocol opts for the use of ketamine and midazolam, first as a bolus followed by a continuous infusion. (Table 2) Because each EMS agency may differ in medication protocols, guidelines will need to consider the access prehospital providers may or may not have to specific medications, as well as the need to provide both analgesia and sedation.

4. Discussion

Once thought to be mutually exclusive, cardiac arrest and consciousness including spontaneous respiration, movement and awareness appears to infrequently co-occur. There is mounting evidence to support the notion that CPRIC exists, however, the strength of this evidence is limited and mainly anecdotal. This paper emphasizes the importance of chest compressions involved in CPR and CCR as improvements in these may lead to improved cerebral perfusion accounting for the CPRIC phenomenon. Increasing utilization of transesophageal echocardiography and real-time compression monitoring may increase rates of CPRIC due to improved cardiac output [40]. It is imperative that more research be done to better describe the physiology involved in these scenarios, the most common presenting behaviors in CPRIC, and populations at-risk of developing CPRIC. There are some new animal studies trying to explain the importance of left ventricular inflow and outflow tract during CPR and impact on cardiac output and potential increase in the incidence of CPRIC [41,42]. Future healthcare teams will be better prepared to take on the challenge of CPRIC with evidence-based guidelines for sedation, analgesia, restraints and patient communication during these events. Lastly, with better records and more rigorous studies of CPRIC the resuscitation community may begin to view the prognostic value of CPRIC events.

Table 2
The Nebraska Model Protocol[a] for Treatment of CPRIC.

Evaluate for signs of consciousness: "spontaneous eye opening, purposeful movements, verbal response."
Administer ketamine bolus • IV: 0.5–1.0 mg/kg • IM: 2–3 mg/kg May repeat ketamine bolus after 5–10 min if needed for continued sedation Consider co-administration of midazolam bolus • IV: 1 mg Start ketamine infusion • IV infusion: 2–7 μg/kg/min

[a] Rice DT, Nudell NG, Habrat DA, Smith JE, Ernest E V. CPR induced consciousness: sedation protocols for this special population. Br Paramed J 2016;1:24–9.

From the cases presented in this review, it is clear that there is no agreed upon management strategy CPRIC (Table 1). Olaussen et al. demonstrated that there is in fact a desire among practitioners to consult guidelines during this type of unusual situation [21]. Four cases reported the use of sedation with ketamine and midazolam being most common [20,23,24,29]. One case used physical restraints to prevent the patient from interrupting resuscitation [25]. Use of physical restraint may not be a preferable strategy as it can cause possible injury if the patient continues to resist. The successful use of verbal communication with the responsive but interfering patient was demonstrated in only one case study [28]. If the patient remains responsive to verbal redirection and instruction, care teams should attempt to calm the patient and explain what is occurring during the resuscitation. Speech during the resuscitation should also be respectful as the patient is able to hear and, in some cases, recall the events of resuscitation with accuracy after return of spontaneous circulation [18,34,43].

More research in the area of CPRIC from the patient's perspective is also required. Patients who survive cardiac arrest are immediately at risk of neurological and psychological consequences. Patients with CPRIC may have anywhere from zero to complete recollection of the resuscitation event as the cases in the article demonstrate. The articles reviewed here suggest that younger patients may be at greater risk of developing a NDE [20]. Patients who survive cardiac arrest should also be assessed for NDE type thoughts at time points beyond the hospital admission as the studies here suggest a possible long-lasting effect of NDE.

National guidelines and authorities should develop protocols for treatment of CPRIC based on their access to and familiarity with analgesic and sedative medications. Use of sedation was considered in several cases but not always given. Provider confidence with sedation may have influenced some of these decisions as no protocol currently exists for management of CPRIC.

In the US, ketamine and midazolam are the most common medications used by EMS that can be considered for treating CPRIC. Collaboration between EMS, emergency physicians and critical care providers would introduce an informative and collective perspective on sedation use in situations such as CPRIC. Although our current data is minimal, treatment of CPRIC does not appear to impact outcomes and may minimize interference with care and prevent potential psychological consequences.

The existing evidence of CPRIC has been compiled in this paper in the hopes that more healthcare providers, especially emergency medicine physicians, will walk away with increased awareness of this phenomenon. By examining this rare event in multiple settings including in and out of the hospital and from two vantage points, the perspective of the patient and the provider, we are able to highlight several opportunities to improve care.

5. Limitations

This review was limited by the lack of large, multi-center, randomized and blinded studies. Case reports made up the majority of the relevant articles in our search. Case reports are helpful for describing rare events like CPRIC, however, they are not the highest level of evidence. The information presented in this article was the best evidence available currently. In this regard, where details of study methods were not clear, we have not tried to clarify these details by contacting the original manuscripts' authors. This study was limited to English-language articles. In addition to the limitations of the included studies, there may be publication bias in which studies were published. Studies that were not published in CINAHL, Scopus, PubMed and/or MEDLINE were not included in this review. With more rigorous studies such as random control trials, meta-analysis and systemic reviews, the resuscitation community could support more theories with quality evidence.

6. Conclusions

Cases of CPRIC should be documented in the literature and in healthcare databases to understand the true prevalence of this issue. Further research is needed to better inform management guidelines and the prognostic value associated with CPRIC. NDE has been shown in the literature to have long lasting effects on the lives of cardiac arrest survivors. With better documentation and future studies, we may be able to elucidate specifics about the experience of cardiac arrest survivors with CPRIC. Patients who display feature of CPRIC should be counseled about psychological sequelae including near-death experience.

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