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Clinical paper

Current practice in pediatric post-cardiac arrest care: a national survey among Italian pediatric intensivists

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Abstract

Background and aims: Pediatric post-cardiac arrest care (PCAC) is an evolving science with many uncertainties leading to many variations in practice. This study aimed to investigate the current practice in PCAC care across Italian paediatric intensive care units (PICUs), interviewing a cohort of pediatric intensivists.

Methods: An electronic survey with 69 questions was distributed to 54 physicians from 23 PICUs in Italy. The survey covered various domains of PCAC care, including hemodynamics, oxygenation and ventilation, sedation, seizure and temperature control, infection treatment, glycemic control, transfusion practice, neuroprognostication, post-CA recovery and rehabilitation, organisation and local protocols.

Results: Twenty-eight out of 54 invited physicians (51%) completed the survey, accounting for 82% of the participating PICUs. Up to 80% reported no specific PCAC protocol in their PICU. Half of the respondents suggested specific recommendations for patients of lower ages, particularly infants. Significant variability was observed in hemodynamic monitoring and support; 45% did not have a specific hemodynamic target, while 41% aimed for a systolic arterial pressure above the 50th age-specific percentile. Seventy-one percent lacked a protocol for target temperature management (TTM), with significant variability in practice. Sixty-four percent did not have a scheduled follow-up program for survivors after hospital discharge. A rehabilitation program for survivors and psychological support for patients and their families were available in half of the instances. Neuroprotective strategies, prognostication, and hemodynamic management were the top PCAC research priorities reported.

Conclusion: The study revealed significant variability in PCAC care practices among pediatric intensivists. The majority of surveyed practitioners evidenced the limits of current PCAC evidence, potentially advocating the need for further research. The top three areas recognised as PCAC research priorities include hemodynamic optimisation, neuroprotective therapies and neuroprognostication.

Keywords: Pediatric, Cardiac arrest, Post-cardiac arrest, Resuscitation

Introduction

Pediatric cardiac arrest (CA) is a major cause of mortality among infants and children globally.[1] There are over 15,000 pediatric in-hospital cardiac arrests (pIHCA) and > 20,000 pediatric out-of-hospital cardiac arrests (pOHCA) each year in the US.[2–5] Data on pediatric CA in Europe are scarce and fragmented.[6] In Italy, pediatric CA accounts for 0.7% of all out-of-hospital cardiac arrests, translating to an annual incidence of 4.5 cases per 100,000 inhabitants,

Abbreviations: CA, cardiac arrest, ILCOR, International Liaison Committee On Resuscitation, PCAS, post-cardiac arrest syndrome, PCAC, post-cardiac arrest care, PICU, pediatric intensive care unit, pIHCApediatric, in-hospital cardiac arrest, pOHCApediatric, out-of-hospital cardiac arrest, SOP, standardised operating procedure, TTM, target temperature management

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representing a rare event.[7] Despite advancements in resuscitation science, morbidity and mortality rates remain alarmingly high.[2,8] Up to 70% of pOHCA and 55% of pIHCA die after being successfully resuscitated.[9] Additionally, survivors often endure long-term neurological and cognitive impairments that significantly affect their quality of life.[10–12].

Post-resuscitation care with standardised protocols has been associated with improved outcomes.[13–15] However, significant knowledge gaps exist in pediatric post-cardiac arrest care (PCAC), leading to heterogeneity in clinical practice and potentially impacting survival.[16,17] Furthermore, lack of adherence to resuscitation guidelines and PCAS management recommendations has been associated with worse outcomes.[18,19] To date, no study has investigated current practices in PCAC in Italy. Such evidence would be valuable in identifying domains of PCAC that could be developed further in future clinical trials. We hypothesised that pediatric PCAC in Italy is not homogeneous and aimed to estimate the differences.

Method

Survey development and distribution

A web-based electronic survey was designed to investigate PCAC practices in Italy. The initial draft of the survey was reviewed by members of the Italian Resuscitation Council (IRC) scientific committee, and their feedback was incorporated into the final version. The survey was pre-tested by pediatric intensivists not involved in the project to ensure quality and relevance. Survey invitations were sent by an Italian network administrator to a cohort of pediatric intensivists from 23 pediatric intensive care units (PICUs) in Italy, 22 of them being part of the Italian Network of PICUs (TIPNet) study group. The TIPNET research network mailing list includes the PICU directors and the local investigators (up to two per centre) for every participating site. The invitations were distributed between October 1 and November 31, 2023. Weekly reminders were sent to non-respondents until the survey was completed or the distribution period ended.

The survey was designed using the Research Electronic Data Capture (REDCap) tools hosted at Istituto di Ricovero e Cura a Carattere Scientifico Ca' Granda Ospedale Maggiore Policlinico.[20,21] REDCap is a secure, web-based software platform powered by Vanderbilt University, Nashville, Tennessee, USA, that supports data capture for research studies.[20,21]

The survey contained 69 questions regarding different pediatric PCAC domains, including organisation and local protocols, hemodynamics, oxygenation and ventilation, sedation, seizure management, infection treatment, temperature management, glycemic control, transfusion practice, neuroprognostication and post-CA recovery and rehabilitation (Appendix A). The questions were based on current knowledge regarding PCAS in adults, children and infants.[9,17] The survey included a mixture of single and multiple-choice questions, as well as open-ended (free text) questions.

Ethical considerations

The survey adhered to the ethical standards outlined in the Declaration of Helsinki. Participation was voluntary, and no incentives were offered. No personal or sensitive information was requested or collected, and all responses were anonymised. The authors classified the survey as a quality improvement project, and no experimental, patient, or personal data were recorded or analysed. Consequently, ethical approval from local committees was not sought.

Data analysis

Only data from completed surveys were included in the analysis, with partial responses excluded. Descriptive statistics were employed to summarise the responses. Continuous data are presented as median and interquartile range, and categorical data as frequency and percentage. Data were exported from the RedCAP platform into the Statistical Package for the Social Sciences (SPSS version 28.0.0, 2021; IBM Corporation).

Results

General information

We received 31 responses from 54 survey invitations sent during the distribution period. Among these, 28 responses were complete and were included in the analysis, representing 82% of the participating PICUs. Most responses arrived from participants reporting fewer than 50 pediatric wards and 6 PICU beds (42.9% and 50.0%, respectively) in their hospital. Different age limits were reported to define a patient as "pediatric", ranging from 14 to 18 years, with 70% of responders using 18 years as the pediatric age limit. The median number of pediatric CA patients managed by the respondents over two years was 5 [3;6], with significant variability among respondents (Fig. 1). Most PICU intensivists (78.6%) reported the lack of any standardised operating procedure (SOP) for general PCAC. Additionally, 53.6% indicated that specific age groups, particularly infants under 1 year old, should be managed with dedicated recommendations or protocols.

Hemodynamic management

Hemodynamic monitoring practices varied significantly. Over 90% of respondents stated to rely on clinical signs, serial lactate measurements, central venous and invasive arterial pressure, and transthoracic echocardiography during PCAC. Seventy-five percent of respondents used end-tidal carbon dioxide (EtCO2) and 71.4% near-infrared spectroscopy. Other monitoring techniques were less frequently reported (Fig. 2). Around 43% targeted a systolic arterial pressure above the 50th age-specific percentile during hemodynamic optimisation. However, a similar proportion of physicians did not reported any specific pressure target. Noradrenaline and adrenaline were commonly considered by more than 80% of respondents in cases of a cardiocirculatory shock and hypotension unresponsive to fluid resuscitation. Adrenaline and milrinone were generally preferred for patients in shock but not hypotensive by 64.3% and 57.1%, respectively (Fig. 3). Notably, 64.3% of respondents reported the lack of extracorporeal life support availability in their institutions.

Ventilation management

Over 90% of participants stated to ventilated PCAC patients with tidal volume between 6 and 8 ml/kg. The upper limit of plateau pressure accepted during invasive mechanical ventilation was lower than 28 cmH_2O for up to 70% of respondents. Specifically, 28.6% chose 26 cmH_2O, and 42.9% chose 28 cmH_2O as the accepted plateau pressure limit. Regarding gas exchange, arterial oxygen saturation levels between 90–94% and 94–98% were preferred by 39.3% and 53.6% of respondents, respectively. Similarly, arterial carbon dioxide

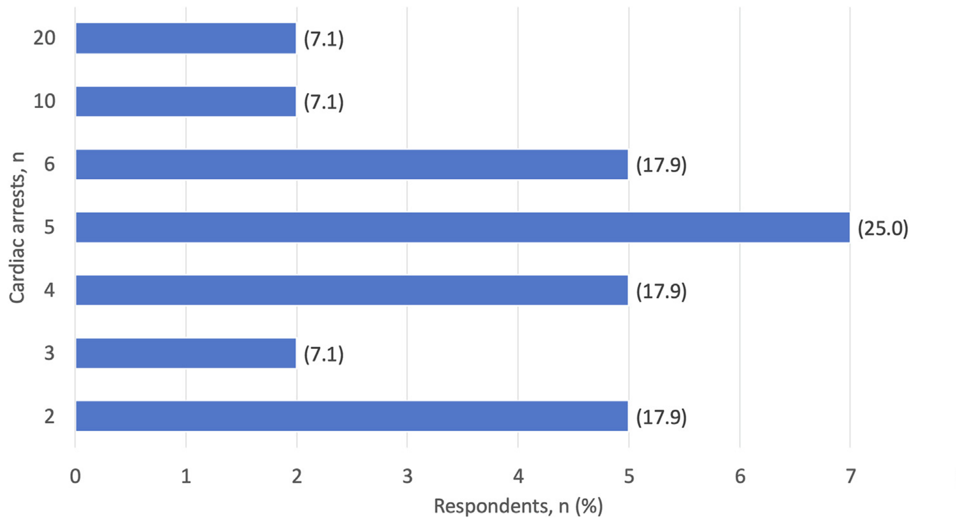

Fig. 1 – Patients admitted to PICU after pediatric cardiac arrest in a two-year period (2022–2023).

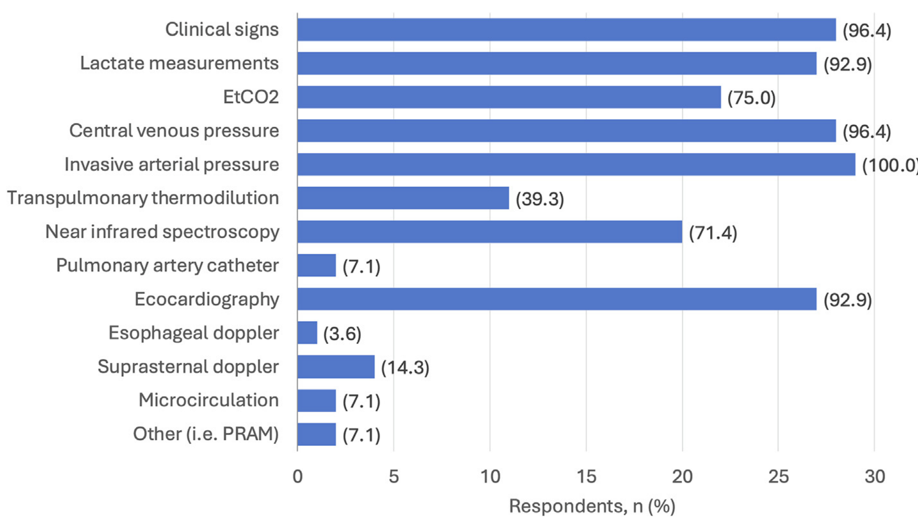

Fig. 2 – Hemodynamic monitoring used in pediatric post-cardiac arrest patients.

levels in the range of 35–40 mmHg and 40–45 mmHg were favoured by 60.7% and 25.0% of respondents, respectively.

Sedation and seizure control

Three out of four respondents reported to routinely sedate PCAC patients after ICU admission. The preferred sedative drugs were midazolam (81%), fentanyl (71.4%), and dexmedetomidine (66.7%). Sedation monitoring was routinely described by 52.4% of respondents. Two-thirds of respondents used neuromuscular blocking agents, primarily when targeted temperature management (TTM) was employed (52.4%). These agents were preferably administered as a continuous infusion (85.7%) rather than intermittent boluses (14.3%).

Sixty-eight percent described the use of neurophysiological monitoring for seizure detection, while 14.3% used it only in sedated patients. Intermittent and continuous electroencephalography (EEG) were equally preferred as monitoring techniques (34.8 and 39.1%, respectively). The use of more sophisticated neurophysiological monitoring, such as amplitude-integrated EEG, was reported by 26%. Antiseizure medications were prescribed by 75% of respondents only in cases of clinical or EEG-monitored seizures.

Targeted temperature management

Seventy-one percent of the respondents reported the lack of SOP for temperature management in PCAC. Various methods for measuring body temperature were described, with a preference for core body temperature measurement (Table 1). Continuous temperature monitoring was prefered by 85.7% of intensivists, while the remainder measured temperature intermittently every 1 to 8 h.

Approximately 18% of respondents cooled PCAC patients, maintaining body temperature between 32 and 36 °C. Among this subgroup, 60% continued the cooling phase 24 h after ICU admission. Up to 40% reported the use of cooling devices with temperature feedback and servo-control regulation to maintain target temperature. All respondents declared to control the rewarming speed, increasing body temperature from 0.1 to 0.5 °C per hour. After rewarming, around 60% claimed to actively prevent temperature rebound and 40% to treat temperature rises only when severe

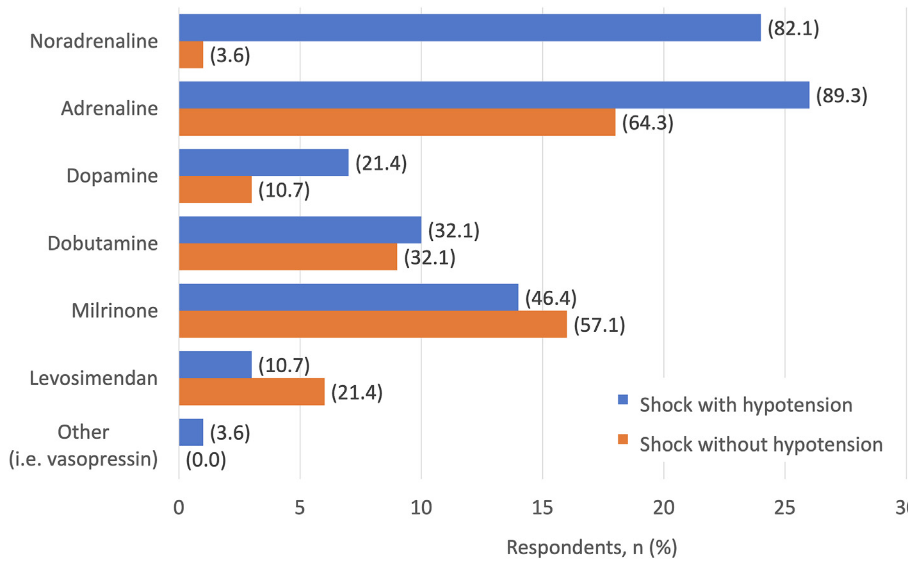

Fig. 3 – Drug selection in case of shock refractory to fluid resuscitation in pediatric post-cardiac arrest patients.

Table 1 – Temperature control practice in pediatric post-cardiac arrest patients.

Do you have a standard operating procedure for target temperature management?	Yes	8 (28.6)
How is body temperature measured?	External cutaneous temperature	4 (14.3)
	Esophageal probe	4 (14.3)
	Rectal probe	6 (21.4)
	Urinary catheter probe	8 (28.6)
	Intravascular probe	2 (7.1)
	Other	4 (14.3)
Is body temperature measured continuously?	Yes	24 (85.7)
If body temperature is not measured continuously, how often is it obtained? (out of 4)	1 h	1 (25.0)
	2 h	1 (25.0)
	3 h	1 (25.0)
	8 h	1 (25.0)
During target temperature management, are patients initially cooled to 32–36 °C?	Yes	5 (17.9)
Target Temperature Management 32–36 °C (n = 5)		
What is your temperature target during cooling?	32–34 °C	2 (40.0)
	34–36 °C	2 (40.0)
	32–36 °C	0 (0.0)
	Other	1 (20.0)
How long is cooling maintained?	24 h	3 (60.0)
	48 h	1 (20.0)
	72 h	1 (20.0)
Which system are used to reach and maintain target temperature?	Ice packs, cold-air mattress	3 (60.0)
	Cold intravenous fluid	0 (0.0)
	Surface cooling method	1 (20.0)
	Intravascular cooling method	2 (40.0)
	Other	0 (0.0)
With temperature feedback and servo-control regulation? (out of 3)	Yes	3 (100.0)
After the cooling phase, is patient rewarming controlled?	Yes	5 (100.0)
What is the rewarming rate (°C/h)?	0.1 °C/h	1 (20.0)
	0.2 °C/h	1 (20.0)
	0.5 °C/h	3 (60.0)

Table 1 (continued)

Do you have a standard operating procedure for target temperature management?	Yes	8 (28.6)
At the end of the cooling phase, are temperature rebound actively prevented or treated?	Always	3 (60.0)
	Only if severe enough to cause fever	2 (40.0)
	No	0 (0.0)
Which system is used to actively prevent or treat temperature rebound?	Ice packs, cold-air mattress	0 (0.0)
	Cold intravenous fluid	0 (0.0)
	Surface cooling method	1 (20.0)
	Intravascular cooling method	0 (0.0)
	Antipiretics drugs	4 (80.0)
	Other	0 (0.0)
With temperature feedback and servo-control regulation? (out of 1)	Yes	1 (100.0)
How long is temperature control maintained after the cooling phase?	Next 24 h after rewarming	1 (20.0)
	Next 48 h after rewarming	0 (0.0)
	Next 72 h after rewarming	4 (80.0)
Normothermia (n = 23)		
If you do not prescribe target temperature management in the range of 32–36 °C, do you actively prevent or treat temperature rise?	Always	12 (52.2)
	Only if is severe enough to cause fever	11 (47.8)
	No	0 (0.0)
Which system is used to actively prevent or treat temperature rise?	Ice packs, cold-air mattress	4 (17.4)
	Cold intravenous fluid	0 (0.0)
	Surface cooling method	5 (21.7)
	Intravascular cooling method	0 (0.0)
	Antipiretics drugs	9 (39.1)
	Other	5 (21.7)
With temperature feedback and servo-control regulation? (out of 5)	Yes	4 (80.0)
How long is temperature control maintained after PICU admission?	Next 24 h	3 (13.0)
	Next 48 h	3 (13.0)
	Next 72 h	11 (47.8)
	Next 96 h	3 (13.0)
	Next 120 h	3 (13.0)

enough to be considered fever. Temperature and fever control were actively maintained for 72 h after rewarming by 80% of respondents (Table 1).

Eighty-two percent stated not exposing PCAC patients to cooling, favouring strict maintenance of normothermia. In this group, 52% declared to prevent or control temperature rebounds actively, the remaining to treat fever. Various methods were described to maintain normothermia, including ice packs and cold-air mattresses (17.4%), surface cooling (21.7%) and antipyretic drugs (39.1%). Almost half maintained temperature control during the first 72 h after PICU admission; notably, 26% continued temperature control from 24 to 48 h, and another 26% from 96 to 120 h (Table 1).

Neuroprognostication

Over 90% of the interviewees reported to initiate the neuroprognostic evaluation within 72 h after PICU admission, with nearly half proceeding within 24 h. EEG and amplitude-integrated EEG were described by 92.9%, while the use of somatosensory evoked potentials (SSEP) were reported by 75%. Brain MRI was chosen by almost 90%, and brain CT by 39.3%. Serum biomarkers were considered by 42.9% of respondents. Specifically, neuronal specific enolase (NSE) was selected by 62.5%, S-100 β by 25% and other biomarkers by 12.5% of those who used biomarkers during neuro prognostication. The three methods considered most reliable in predicting PCAC outcomes were brain MRI, EEG, and SSEP (Fig. 4).

Follow-up and recovery pathway

Only 35.7% of respondents reported a structured longitudinal follow-up for pediatric patients discharged after CA; among them, the first follow-up appointment was described after one month by 80% of those surveyed. Furthermore, 57.1% and 53.6% responded to offer post-discharge rehabilitation and psycho-social support programs for patients and families.

Future perspectives

Seventy-one percent of respondents recognised significant knowledge gaps in PCAC. The three domains identified as research priorities were neuroprotective therapies, neuroprognostication and hemodynamic management (Fig. 5). Eighty-five percent of respondents believed that resuscitated PCAC patients should be managed in specialised institutions with proven experience in CA and PCAC. All respondents expressed interest in participating in a collaborative research network focused on pediatric CA and PCAC.

A complete survey report is contained in the supplementary material (Appendix A).

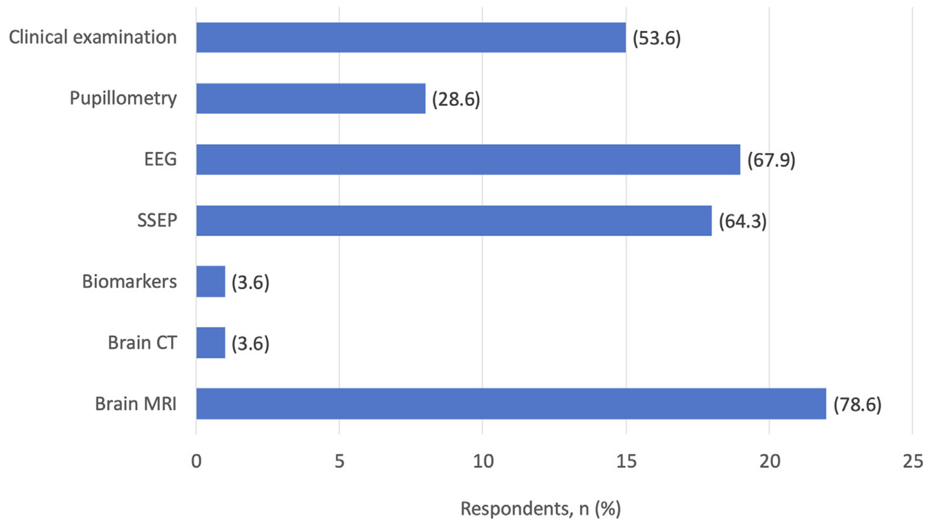

Fig. 4 – Methods considered most reliable for neuroprognostication in pediatric post-cardiac arrest patients.

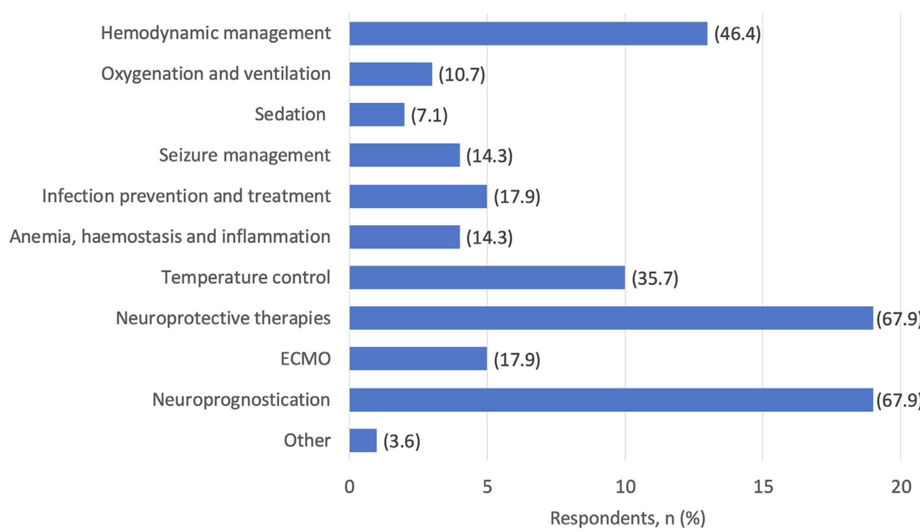

Fig. 5 – Domains considered research priorities in pediatric post-cardiac arrest.

Discussion

This study extensively investigated current practices regarding PCAC among a cohort of Italian pediatric intensivists, revealing considerable heterogeneity. Key domains of PCAC, such as hemodynamic optimisation, neuroprotective therapies and neuroprognostication, were identified as research priorities for future studies and clinical trials. Previous surveys have investigated comprehensive post-resuscitation care in adult patients,[22,23] while analogous studies in paediatrics have focused on specific domains such as temperature management[24–26] and neuroprognostication[27,28]. However, none have comprehensively considered multiple domains of PCAC.[9,17].

The substantial variation in resuscitation practices suggests uncertainty in PCAC,[29] a trend also observed in adult studies.[22,23] Our survey confirmed these findings, with almost half of the respondents working in small-volume pediatric units and PICUs. Although the number of pediatric patients admitted annually was not recorded, the structural characteristics and the regional distribution of PICUs in Italy may partially explain the variability in the number of CA managed by pediatric intensivists.[30] Indeed, half of those surveyed managed less than 5 PCAC patients in the last two years. Infrequent exposure to PCAC patients may impact guideline adherence and increase practice variability, similar to the association between hospital pediatric volume and resuscitation performance.[31,32] Interestingly, a minority of the respondents reported having dedicated SOPs for general and temperature management in PCAC patients. Similar results have been observed in adults, where this finding was associated with the number of PCAC patients treated yearly.[22] This could further strengthen the association between CA patient volume, guidelines adherence and standardised treatments, partially explaining the heterogeneity of responses observed in several PCAC domains.[23,33,34]

We observed significant divergence in the selection of hemodynamic monitoring techniques and cardiocirculatory support drugs. This is significant since hemodynamic instability and myocardial dysfunction are common findings in the first hours after CA.[35,36] Differences in monitoring techniques can be attributed to local resource availability, intensivist preferences, and patient body size limitations. Although advanced hemodynamic monitoring techniques have significant advantages, early clinical signs (i.e. heart rate and systolic arterial pressure) and blood gas analysis (e.g. lactate) have shown a stronger correlation with mortality in pediatric CA.[35,37] No single monitoring technique has demonstrated clear superiority.

Regarding vasopressors and inotropes used in post-resuscitation shock, adrenaline was the first choice in hypotensive and non-hypotensive shocked PCAC patients, aligning with current recommendations for various pediatric shock etiologies.[38–40] Specifically, noradrenaline was preferred for hypotensive shock, while inodilators (e.g. dobutamine, milrinone, levosimendan) were considered more frequently for non-hypotensive shock. The lack of randomised clinical trials makes drug selection in PCAC poorly defined and subject to practitioner preferences.[41] Despite current research gaps, more than half of respondents would titrate hemodynamic support to maintain a systolic arterial pressure higher than the 5th age-specific percentile, consistent with observational data and international recommendations.[37,42,43] Interestingly, only 35.7% of respondents reported having extracorporeal membrane oxygenation (ECMO) support for post-CA patients, indicating limited diffusion of extracorporeal life support in PCAC.

Regarding ventilatory support and gas exchange, pediatric intensivists generally set tidal volume between 6–8 ml/kg and tolerated plateau pressures below 30 cmH_2O. These ventilator settings align with current recommendations for pediatric acute respiratory distress syndrome patients.[44] However, high-quality data supporting these recommendations are limited, and no evidence has specifically translated this approach to PCAC.[39,40] Data on gas exchange targets suggest that practitioners are particularly mindful of maintaining physiological oxygen and carbon dioxide blood tension levels in PCAC patients, as indicated in observational studies.[45–47] This approach is consistent with current guidelines in adults, which describe worse outcomes in resuscitated patients exposed to hypoxia, hyperoxia and hypocapnia after CA.[48]

Temperature control after CA remains a controversial topic.[49,50] Several aspects of temperature control, such as target temperature, cooling method, cooling/rewarming speed, duration, and patient selection, remain undefined.[51–53] This is reflected by the heterogeneity of responses in our survey and the limited use of a dedicated SOP for temperature control (Table 1). In the last decade, the beneficial effects of therapeutic hypothermia in PCAS have been questioned. Based on the results of the THAPCA trials,[54,55] the TTM trials,[56,57] and a systematic review,[58] the ILCOR Pediatric Life Support Task Force suggested actively maintaining a central temperature $\leq$ 37.5° C for infants and children who remain comatose after OHCA or in-hospital cardiac arrest (IHCA).[59] However, the level of evidence was low, so pediatric intensivists might continue prescribing therapeutic hypothermia in selected patients based on expected potential benefits. Indeed, 18% of those surveyed would prescribe temperature control between 32 and 36 °C in the first hours after CA (Table 1). More specifically, the preferred temperature range was 34–36 °C, maintained predominantly for 24 h after PICU admission. Simple cooling methods such as ice packs and cold-air mattresses were more frequently used to induce/maintain cooling. All participants reported controlling patient rewarming, with rates varying from 0.1 to 0.5 °C per hour. The approach to active fever prevention after rewarming was not homogenous. with 60% of respondents actively preventing temperature raises and 40% treating fever once it occurred. Similarly, among practicioners that prefered to maintain normothermia after pediatric CA, 52% actively prevent temperature rebound and 48% treat fever, with antipyretics drugs being the most commonly reported method. Normothermic temperature control was prevalently maintained for 72 h after PICU admission, although similar proportions would select a shorter or a longer period (Table 1).

Despite optimal PCAC, most patients still suffer severe brain injury, making it essential to identify those with a low likelihood of recovery to limit futile treatments.[9,60] In our survey, several risk factors were considered by the participants closely associated with the development of neurological injury: the quality of CPR, the comorbidities, the cause of arrest and witness status were recognised as relevant by almost 70% of respondents. Around 50% do not consider clinical examination precise enough to predict CA outcomes, highlighting the need for ancillary tests.[17] EEG and MRI were considered the most reliable methods for neuroprognostication. Interestingly, a greater proportion of respondents valued SSEP compared to previous reports.[28] The absence of bilateral cortical N20 waves within 7 days after CA has been associated with poor outcomes.[61,62] The best timing for neuroprognostication remains debated, with half of those surveyed initiating the evaluation within the first 24 h. This is significant given the lack of data to inform neurologic prognostication in pediatric CA during the first 3 days. Current evidence suggests that many patients may present a delayed awakening after CA,[63,64] so a “to-early” approach to neuroprognostication might be cautious.[65]

Around one third of practitioners reported having a dedicated follow-up program for pediatric CA survivors discharged home. Up to half of interviewees reported the presence of a specific rehabilitation programs, neurobehavioral and psychological support. Considering the burden of neurocognitive sequelae, a structured approach to rehabilitation after CA should be further encouraged.[66–68].

Limitations

Our study has several limitations. We aimed to maximise the survey response rate by including all collaborators in the TIPNET mailing list. Although our survey covered 82% of the participating PICUs, the response rate (28/54) could have been higher, highlighting the difficulties in conducting web-based self-reported surveys. Additionally, centres received multiple invitations based on the number of collaborators in TIPNET (up to three), which could have partially biased our findings. The survey was anonymous, so we could not link a survey response to a specific respondent. We could only track whether a participant from the invitation list completed the survey or not. Acknowledging this limitation, we focused our results on an individual rather than a site-level analysis. Moreover, the conclusion may not apply to centres that did not respond, centres without a PICU that could occasionally manage PCAC patients or PICUs that do not collaborate with the TIPNET research network. Indeed, we surveyed 23 out of 33 PICUs recently censored in Italy, and we obtained at least one response by 18 of them (54%). Furthermore, we cannot exclude the presence of self-reporting bias in our survey, which means that the responses provided may not fully represent daily practice.

Notwithstanding the above limitations, this is the first study to investigate multiple domains of PCAC and comprehensively provide data on Italian PCAC. More importantly, it facilitated connections among centres and fostered interest in pediatric CA, leading to two significant outcomes: the identification of research gaps considered relevant to practitioners (emphasising the need for research to progress in alignment with clinical needs) and the interest in establishing a collaborative research program (all respondents demonstrated interest in creating a research network focused on pediatric CA and PCAC).

Conclusion

The study identified significant variability in post-resuscitation care practices across Italian PICUs. This variability underscores the urgent need for further research and data collection, particularly in hemodynamics, neuroprotective strategies and neuroprognostication, which remain highly uncertain. The next phase involves disseminating this survey to PICUs across Europe to establish a collaborative research network. Such a network would facilitate the sharing of interests and goals, ultimately aiming to standardise care and implement best practices in PCAC.

CRediT authorship contribution statement

Giovanni Babini: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Alberto Cucino:** Writing – review & editing, Data curation. **Giuseppe Stirparo:** Data curation. **Giuseppe Ristagno:** Writing – review & editing, Supervision. **Carlo Agostoni:** Supervision. **Mirjana Cvetkovic:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Giovanni Babini reports a relationship with LUM Giuseppe Degennaro University that includes: speaking and lecture fees. Giovanni Babini reports a relationship with Italian Resuscitation Council that includes: non-financial support and travel reimbursement. Alberto Cucino reports a relationship with Italian Resuscitation Council that includes: board membership, non-financial support, and travel reimbursement. Giuseppe Stirparo reports a relationship with Italian Resuscitation Council that includes: non-financial support and travel reimbursement. Giovanni Babini, Alberto Cucino and Giuseppe Stirparo are members of the Scientific Committee of the IRC. Alberto Cucino is member of the Executive Committee of the IRC. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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