Barriers and Facilitators of Intensivists' Adherence to Hyperinsulinemia-Euglycemia Therapy in the Treatment of Calcium Channel Blocker Poisoning

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Abstract

Introduction Adherence to poison center (PC) recommendations for the management of calcium channel blocker (CCB) poisoning is inconsistent. This study aimed to identify behaviors that determine adherence to hyperinsulinemia-euglycemia therapy (HIET) for CCB poisoning.

Methods Semistructured interviews were conducted involving a convenience sample of 18 intensivists. Interview responses were analyzed using the theoretical domains framework (TDF) to identify relevant domains influencing physician adherence to HIET. Two independent reviewers performed qualitative content analysis of the interview transcripts to identify beliefs influencing decisions to initiate HIET. Initially, beliefs were classified and frequencies reported as being likely to facilitate, likely to decrease, or unlikely to affect adherence. Subsequently, beliefs were linked to a domain within the TDF. Based on the potential impact on physician behavior and frequency of reported behavior, we selected the most relevant domains likely to influence physician adherence to HIET for CCB poisoning.

Results Positive beliefs were identified in the following domains: “*behavioral regulation*” (e.g., algorithm for adjustment of perfusions), “*belief about capabilities*” (e.g., confidence about being able to manage HIET), “*belief about consequences*” (e.g., fear of clinical deterioration), and “*reinforcement*” (e.g., clinical instability). Negative beliefs were identified in the following domains as “*nature of behavior*” (e.g., preference for vasopressors over HIET) and “*environmental context and resources*” (e.g., accessing dextrose 50% and increased nurse workload).

Conclusion This qualitative study identified potential behavioral targets for future implementation strategies to address to improve adherence to HIET.

Keywords Calcium channel blocker · Cardiotoxicity · Knowledge transfer · Implementation · Adherence

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Introduction

Calcium channel blocker (CCB) poisoning is a major problem associated with significant morbidity and mortality. According to the National Poison Data System (NPDS), approximately 13,345 exposures (including 5493 single exposures) to CCB poisoning occurred in the USA in 2016, which contributed to 26 deaths and 72 major complications [1]. Over the last two decades, novel treatment strategies have been proposed for managing patients with severe CCB poisoning. Hyperinsulinemia-euglycemia therapy (HIET) has been linked to positive outcomes in case series and observational studies [2–4]. This therapy is proven to be safe and is commonly a part of poison center (PC) treatment recommendations for CCB and beta-blocker poisoning [1]. Nevertheless, research on this topic has demonstrated that

there is a low adherence rate to PC recommendations (42%) when treating CCB poisoning [5, 6]. In particular, HIET has been identified as the therapy for which there is the lowest adherence rate [5, 6]. However, an expert consensus statement for the management of CCB poisoning was endorsed by many medical toxicology and critical care societies and associations around the world [7], which recommends the use of HIET for CCB poisoning as a first-line therapy, despite the low level of evidence.

Although frequent barriers and facilitators to guidelines implementation have been described [8–12], published studies to date about factors influencing adherence to PC recommendations have been limited. To facilitate the study of implementation of evidence-based practice, searchers, psychological theorists, and health psychologists have developed the theoretical domains framework (TDF), an integrative framework derived from many behavioral change theories and concepts [13, 14]. The TDF was used as a tool to study psychological factors contributing to health-care professionals' behaviors in many studies [8, 15–17]. By identifying barriers and facilitators to adherence, specific implementation strategies can be used to facilitate knowledge transfer and promote guidelines adherence. Tailored implementation strategies based on physician and health-care professional-perceived barriers and facilitators have been suggested to promote adherence [18–21].

The present study aimed to assess the behavioral determinants of adherence to HIET for the treatment of CCB poisoning. A better knowledge of these behavioral determinants might improve collaboration between bedside clinicians and PCs and thereby facilitate knowledge transfer.

Methods

We used the TDF to study adherence to HIET for the treatment of CCB poisoning. This framework has 14 theoretical domains that influence behavior (Table 1) [13, 14, 22]. The TDF constitutes an integrative framework of many behavioral change theories and concepts that can help intervention designers to select implementation strategies focused on identified barriers. The TDF was issued from a consensus of 64 psychological theorists, health researchers, and health psychologists and has largely been used in implementation research for healthcare professionals. It was designed to simplify and integrate many behavior change theories and concepts in order to make it more accessible and easier to use. The TDF was afterwards validated with experts in behavior change theory who were unaware of the framework. They were asked to sort 112 theoretical constructs from different behavior change theories into clusters [14]. Considering that TDF is a comprehensive,

Table 1 Domains of the TDF

Domain	Definition
“Knowledge”	Refers to awareness of a condition, such as the underlying treatment recommendations and scientific rationale
“Skills”	Refers to the competencies involving the abilities and the coping strategies that allow clinicians to apply knowledge to a patient
“Social/professional role and identity”	Refers to professional identity, i.e., the role associated to this identity and related boundaries
“Beliefs about capabilities”	Also considered as self-efficacy, it is the domain of perceived competence, professional confidence, and perceived behavioral control
“Optimism”	Refers to the confidence that things will happen for the best or that desired goals will be attained
“Beliefs about consequences”	Refers to the perception of anticipated outcomes
“Reinforcement”	Refers to specific incentives or sanctions concerning a behavior
“Intention”	It evaluates the intensity of a conscious decision to perform a behavior
“Goals”	Refers to objectives and priorities that an individual wants to achieve
“Memory, attention, and decision processes”	Refers to the abilities to retain information, focus selectively on aspects of the environment, and choose between two or more alternatives
“Environmental context and resources”	Refers to the circumstances that discourage or encourage the development of skills, abilities, independence, social competence, and adaptive behavior (e.g., time, material, and human resources)
“Social influences” (a.k.a. social norms)	Refers to what others do as well as the judgment of others or conflicts with colleagues or other professionals that might affect a clinician's behavior
“Emotion”	It is the domain that denotes the emotional response to a specific behavior
“Behavioral regulation”	Refers to action planning, to the effect of habit and past behaviors, and to feedback that contributes to behavior implementation

validated framework that has frequently been used by health-care researchers, we selected the TDF as the most appropriate framework to help us identify participants' beliefs (e.g., barriers and facilitators) about adherence to HIET for the treatment of CCB poisoning. A belief is a collection of utterance responses that is supported by similar or identical statements by multiple participants [23].

We recruited a convenience sample of Canadian intensivists for the present study. The only inclusion criterion for recruitment was to be a specialist in critical care medicine, while clinicians with training in toxicology were excluded. An invitation letter was sent to intensivists across Canada through an electronic mailing list of members provided by the Canadian Critical Care Society, explaining the purpose of the study and inviting them to participate in semistructured telephone interviews. With approval from the research ethics board at the CHU de Québec, Québec, Canada, we offered participants a chance to win a paid registration to a critical care conference as an incentive to participate.

Recruitment occurred in a stepwise approach. We initially did not recruit enough participants through the invitations sent to the mailing list; thus, we recruited additional participants by sending invitation letters through academic critical care departments in the provinces of Ontario and Quebec, with the possibility of extending the invitation afterwards to other Canadian academic centers if it was necessary to recruit more participants. The participants who we recruited were limited to being located in these two Canadian provinces.

We recruited participants until we reached a saturation of TDF-related beliefs during the interviews [24, 25]. Interview recordings were transcribed verbatim and we classified the answers in the corresponding domains of the TDF. When no new belief (i.e., no new collection of similar responses explaining the behavior) emerged during the interviews, we interviewed six additional participants to ensure that no new belief would emerge and then stopped the recruitment. Following saturation, an intensivist who responded to the invitation was not interviewed and it was deemed to be not necessary to extend the invitation to other academic centers to recruit more participants.

One interviewer (EB) conducted semistructured interviews in the French or English language aimed at identifying participants' beliefs about adherence to HIET for the treatment of CCB poisoning. We conducted 15 (83.3%) interviews in French. To ensure all quotes maintained the original meaning, one investigator translated the verbatim transcripts from French to English and another investigator translated them back from English to French. We compared our translations to ensure that the original meaning was maintained [26, 27]. Divergent translations were resolved through discussion until a translated quote keeping the original meaning was obtained by consensus between the two reviewers.

Questions were designed to cover each of the 14 theoretical domains of the TDF with, at minimum, one question. All domains were explored using open-ended questions that were designed by a consensus among the authors (EB, MS, PA). We also included demographic questions concerning the base specialty of training, level of experience, and frequency of patients with CCB poisoning encountered per year. Telephone interviews were held in September 2016 at a convenient time for participants. Prior to the interview, participants received the list of questions that would be asked (Appendix 1) and a treatment protocol for CCB poisoning that was based on a published international expert consensus statement [7]. The reference for the consensus statement was quoted at the upper part of the treatment algorithm for a clear reference. Participants were encouraged to read the questions and the treatment algorithm prior to their interview.

Analysis

Interview transcripts were analyzed in their respective native language. Beliefs were identified in participants' responses and were classified in relevant domains of the TDF. Because interview questions were designed to explore all domains of the TDF, most questions were already linked to specific domains. If an answer to an open-ended question revealed a new belief that was relevant to another domain, that belief was classified in all appropriate domains. This deductive qualitative content analysis of each interview transcript was performed using a methodology inspired by previously published studies using the TDF [8, 28].

Each answer from all 18 participants was classified by two independent reviewers (EB, GL) as either likely to facilitate, likely to prevent, or unlikely to affect adherence. If a participant's answer appeared to the investigators as unlikely to affect their adherence to HIET treatment recommendations, we classified the answer as neutral. When a participant's answer was identified as a potential barrier or facilitator to the use or the adherence to HIET, we classified the answer as likely to facilitate or likely to prevent adherence. Similar or identical answers by different participants were identified as beliefs and listed subsequently, according to the corresponding domain. The classification of answers independently made by the two reviewers was then compared, with disagreements resolved through discussion. When the two reviewers did not classify an answer in the same way (e.g., one considering that the answer was neutral and the other considering it as likely to facilitate or likely to limit adherence), they re-read the verbatim and discussed the impact of the response on the participant's behavior until they agreed. To identify relevant domains affecting participants' adherence to HIET, we used the recurrence of beliefs among participants and the impact on the

adherence to HIET of the participants' responses (i.e., a belief that appeared to affect adherence to HIET in participants' statements regardless of the frequency of which it was reported). For example, if a barrier of interest was reported by only one participant but was pertinent in explaining the use or adherence to HIET, it was considered independently of the frequency. A belief identified in a single or a small number of participants can be relevant to explain behaviors even if it is not reported by others and it can help to identify barriers that others have not observed or confronted. When a belief was recurrent in more than one participant, we calculated the number of recurrences and reported it in our results. The percentages that are reported in the results are the frequency at which the beliefs were reported by participants and do not necessarily represent the percentage of participants considering each belief as a barrier or a facilitator. Since clinicians do not necessarily have a homogeneous practice, domains can be identified as limiting adherence among some participants and facilitating HIET's use by others. Thereby, identified beliefs affecting adherence to HIET are not necessarily generalizable to all clinicians.

Results

Participant Characteristics

Eighteen participants were interviewed. Physicians included in this study were intensivists without additional toxicology training working in nine different academic hospitals in Quebec and Ontario. Our sample included intensivists trained in different baseline specialties (e.g., internal medicine, anesthesia, and respirology). They varied in terms of type of practice (e.g., mixed with base specialty versus exclusive critical care practice) and number of years of experience (Table 2). They all had previous experience managing patients with CCB poisoning and had used HIET in the past. We identified all beliefs in the first 12 participants' interviews. We conducted interviews for six additional participants to ensure that no new belief emerged [24, 25].

Beliefs Likely to Facilitate the Use of HIET

In the “*knowledge*” domain, the perception of HIET as a major component of the PC protocol was identified as a belief positively influencing the intention to adhere to HIET [72.2% (13/18)]. The strength of the evidence behind HIET was considered as a facilitator by one-third of participants [33.3% (6/18)]. Understanding the mechanism of action of HIET reinforced the importance of its implementation for seven out of 18 clinicians. In the “*skills*” domain, adherence was positively impacted when clinicians considered HIET as an easy therapy to use [50% (9/18)]. The “*belief about capabilities*” domain

Table 2 Participant characteristics

Characteristic	Number of participants (n = 18)
Baseline specialty	
Internal medicine	10
Anesthesiology	7
Respirology (respiratory medicine)	1
Type of practice	
Mixed	10
Exclusive	8
Years of experience	
0–5 years	8
5–10 years	4
More than 10 years	6
Exposure to patients with CCB poisoning	
0–2 cases per year	15
3–5 cases per year	3
More than 5 cases per year	0

was considered to be a facilitator because most participants felt confident about managing HIET and its potential complications [66.7% (12/18)]. In the “*social/professional role and identity*” domain, credibility given to the PC was a positive belief for adherence to HIET [83.3% (15/18)].

Some clinicians reported that they feared that an unfavorable clinical outcome would happen if they did not use HIET [83.3% (15/18)]. The majority of clinicians considered the risk–benefit ratio as being favorable [72.2% (13/18)]; therefore, “*belief about consequences*” was a domain with a positive influence on adherence to HIET. In the “*reinforcement*” domain, clinicians reported clinical instability, severe intoxication, and progression to a vasoplegic state as incentives for applying HIET. Most participants stated having the intention of using HIET [66.7% (12/18)]. Consequently, the “*intention*” domain was seen as a facilitator for the implementation of HIET.

In the “*memory, attention, and decision process*” domain, participants felt it was intuitive to consider using HIET for every CCB-poisoned patient [88.9% (16/18)]. Participants also considered that suggestions from PCs to initiate HIET were helpful in clinical decision-making [88.9% (16/18)]. “*Environmental context and resources*” was another domain that positively influenced adherence to HIET because most clinicians viewed the necessary resources as being accessible [83.3% (15/18)]. When discussing “*social influences*,” some clinicians perceived that it was easier to use HIET when colleagues also regularly used it [38.9% (7/18)]. Most participants also considered PC recommendations as the standard of care [66.6% (12/18)]. In the “*behavioral regulation*” domain, the following positive beliefs were identified: processes

or strategies that could facilitate the implementation of HIET [83.3% (15/18)], positive past experiences with HIET [72.2% (13/18)], and consideration of HIET as being a standard treatment [50% (9/18)] (Table 3).

Beliefs Likely to Prevent Adherence

In the “*skills*” domain, many participants reported that increased nursing workload complicated the use of HIET [44.4% (8/18)]. In the “*belief about capabilities*” domain, participants [50% (9/18)] mentioned having to reassure nurses about the high doses of insulin used in HIET. In the “*memory, attention, and decision processes*” domain, the following factors were identified as potential barriers: having a patient stabilized with minimal vasopressor support or having a patient with hypoglycemia or hypokalemia [66.7% (12/18)]. In the “*social influences*” domain, three clinicians downplayed PC recommendations about initiating HIET as being optional as opposed to being a standard of care, potentially contributing to limited adherence to HIET. In the “*behavioral regulation*” domain, greater comfort with commonly used vasopressors (e.g., norepinephrine and epinephrine) was reported as being a limiting factor to early HIET initiation [38.9% (7/18)]. Managing other life-threatening situations or organizing a transfer to an extracorporeal membrane oxygenation-capable hospital were “*goals*” potentially interfering with the early initiation of HIET [22.2% (4/18)] (Table 4).

Conflicting Beliefs and Factors Unlikely to Affect Adherence to HIET

“*Optimism*” about HIET efficacy was found to positively influence clinical decisions in 11 out of 18 participants (61.1%). In contrast, three participants were pessimistic about the efficacy of HIET, stating that other novel therapies in critical care have been invalidated by high-quality controlled trials [29]. In the “*social influences*” domain, three clinicians reported having experienced opposition to the use of HIET by colleagues or other professionals. However, participants believed that this barrier could easily be overcome and would not influence their decision to use HIET. In the “*knowledge*” domain, only one participant considered HIET as a rescue therapy, whereas another stated that the low quality of available evidence for HIET was a major reason to favor vasopressors.

In the “*social/professional role and identity*” domain, two participants reported that PC recommendations to initiate HIET were viewed as a limitation to professional autonomy because they felt pressured to follow the recommendations. However, this negative belief did not influence their adherence to HIET. In the “*belief about capabilities*” domain, one clinician did not feel confident about managing HIET, but stated that PC support was helpful to address this barrier. When asked about “*environmental context and resources*,”

one participant mentioned that lack of accessibility to the necessary resources was a limiting factor. For example, there was limited access to a sufficient quantity of dextrose 50%. In the “*goals*” domain, no conflicts between PC treatment recommendations and other guidelines were reported (Table 5).

Discussion

The present study identified the main facilitators and barriers to HIET adherence via a structured interview format. While certain beliefs were infrequently reported, they still appear relevant because they contributed to a better understanding of adherence to behavior. In contrast, some other beliefs were reported more frequently, but might not strongly influence behavior, since our study cannot measure the weight of each belief on behavior.

Although we have identified studies that have explored patient adherence to PC recommendations [30–32], to our knowledge, no study to date has explored the barriers to and facilitators of clinician adherence to PC recommendations. A few studies have identified beliefs that influence practice guidelines implementation among intensivists [12, 33–39]. Certain barriers identified through the present study could be relevant to the implementation of other novel therapies or time-consuming treatments for critically ill patients. A single study on clinician adherence to guidelines for the prevention of ventilator-associated pneumonia identified barriers similar to those that we identified [12]. This includes disagreement with the interpretation of evidence, unavailability of resources, adverse effects, and nursing workload.

We identified barriers that PC medical directors can now focus on to facilitate the use of HIET. In particular, a protocol to guide the initiation as well as the adjustment and weaning of an insulin drip would be a useful tool. Participants also stated they needed advice on which target to use while adjusting the perfusion rate as well as the frequency of blood glucose and potassium measurements.

Our results also highlight the importance of a multidisciplinary approach to improve HIET adherence for the treatment of CCB-poisoned patients. We identified barriers directly related to communication breakdown and the need for better interprofessional collaboration with nurses and pharmacists. Participants stated that PCs could do a better job with explaining the underlying scientific rationale, peer-reviewed literature, and expected outcomes for HIET so as to empower bedside clinicians including nurses to safely use HIET. To minimize errors and facilitate drug administration, pharmacists should be involved early in the process to ensure that the proper infusions of insulin and dextrose are available. The development of better bedside knowledge tools specifically designed for use by physicians, nurses, and pharmacists

Table 3 Beliefs contributing to adherence to HIET

Domain	Beliefs by domain	Relevant sample quotes	Frequency of the belief (n = 18)
Knowledge	Perceived place for the use of HIET in the PC protocol	<i>Very early, I do my ABC, quickly give the calcium, the vasopressors are started, [and] then I give insulin. It is not a rescue therapy, I start it at the moment at which I start vasopressors.</i>	13 (72%)
	Strength of evidence supporting HIET	<i>We know that the strength of the evidence in toxicology will never be double-blind RCT with 1000 patients, so, when experts suggest something, I will try it and if it works, it's enough for me.</i>	6 (33%)
Skills	Knowledge behind the mechanism of action and reasons why it is recommended	<i>Yes, it is good to know that there is logic behind it. This logic encourages me to use it.</i>	7 (39%)
	Ease to proceed to HIET when it is indicated in comparison with vasopressor initiation	<i>I print a sheet and I sign at the end of it. Doses of insulin and dextrose are indicated; we adjust after if necessary. It's easy to get started and to adjust; nurses in the ICU and emergency department are comfortable adjusting it. I only have to say "CCB poisoning" and we have a pharmacist who will arrive with a box with everything we need. It is extremely helpful.</i>	9 (50%)
Social/professional role and identity	When suggested, effect of credibility given to the PC regarding the decision to initiate HIET		15 (83%)
	Impact of PC treatment recommendations on the management of a CCB-poisoned patient and influence on decisions	<i>It must be part of the discussion [so that] the intensivist at the bedside has a sense of which direction the patient is going, I tend to follow, but I think a discussion is necessary with the toxicologist.</i> <i>I don't feel obliged to follow the protocol when a patient is not fitting in. If I have a patient with a baseline ejection fraction of 20%, I might go directly to ECMO. The protocol is an elegant way of doing things for an undifferentiated patient.</i> <i>No impact. I remain the physician in charge of the patient.</i>	13 (72%)
Belief about capabilities	Impact on professional identity and autonomy when the PC suggests to initiate HIET		
	Being confident about managing HIET and related complications	<i>Very comfortable. The only discomfort is later, when the patient begins to improve and we begin to wean the vasopressors. It is more complicated given the half-life; it is easier to initiate, but the weaning is more complicated.</i> <i>It is still tough, [but] the experts of PCC reinforce my confidence that I don't have by myself.</i>	12 (67%)
Belief about consequences	Anticipation about what will happen if HIET is not used	<i>The patient could deteriorate; he could have organ dysfunction and he may die.</i>	15 (83%)
	Influence of risk–benefit ratio on the decision to initiate HIET	<i>The risk is hypoglycemia, the benefit is to wean the vasopressors, so if the patient has high doses that are increasing, the benefit will be higher; but, if I have small doses of vasopressors, the risk is greater than the benefit.</i> <i>The risks are high compared to the benefits; it is not a trivial therapy, but it can be life-saving and can help avoid other therapies that are not trivial, such as high doses of vasopressors.</i>	13 (72%)
Reinforcement	Incentives underlying the decision to initiate HIET	<i>A patient who rapidly needs vasopressors; the more unstable the patient is; a clear history.</i> <i>Definitely the dose of medication taken is going to be a factor: if the patient has taken a lot, I will probably start it sooner.</i> <i>If the patient is very, very, very ill, I will initiate it before. If I had not started it, and the patient becomes less responsive to treatment, I certainly will start it.</i>	18 (100%)
Intention	Level of motivation to initiate HIET in a CCB-poisoned patient	<i>Really motivated. It is what I am going to do. It is like giving antibiotics for pneumonia.</i>	12 (67%)
Memory, attention, and decision processes	HIET being something usually used	<i>Usual when a patient has hemodynamic instability.</i>	12 (67%)
	Intuition to consider HIET in a patient with CCB poisoning	<i>I consider it all the time, but it depends on the severity of the illness.</i>	16 (89%)
	Influence of PC recommendations on the decision-making process to initiate HIET	<i>Generally, when they recommend it, it is indicated and has a direct impact. I strongly consider it when recommended.</i>	16 (89%)

Table 3 (continued)

Domain	Beliefs by domain	Relevant sample quotes	Frequency of the belief (n = 18)
Environmental context and resources	Resource accessibility required to administer HIET	<p><i>Maybe this will make me change my mind if I was initially ambivalent.</i></p> <p><i>If you have only one patient who is unstable in your unit, it is okay, [but] if you admit at the same time a polytrauma patient who is exsanguinating and my CCB-poisoned patient is with an epinephrine infusion with a blood pressure of 85, I will not start insulin. In general, the resources are there when needed.</i></p>	15 (83%)
	Effect of colleague use of HIET on decision to use it	<p><i>Yes, I think peer pressure facilitates the use of it, but I have enough evidence which convinced me to do it, so (...)</i></p> <p><i>Yes, I have always had the impression that among my colleagues there is an acceptance that this therapy is beneficial. I do not feel divergent in my practice and it reassures me.</i></p>	7 (39%)
Behavioral regulation	Consideration of PC treatment recommendations as standard of practice or as an option	<i>It all depends on the case, but, if suggested, I think it should be done. A very strong treatment option or a standard if there is no contraindication. The difficulty is that we must communicate the severity of the intoxication; otherwise, the recommendation is not necessarily valid if they do not see accurately the problem.</i>	12 (67%)
	Processes or strategies that would facilitate implementation of PC treatment recommendations	<p><i>I think that standardized prescriptions/protocols for insulin and dextrose would facilitate the implementation of these recommendations. Protocols with a frequency of glycemia measurement and labs would help.</i></p> <p><i>A protocol that has not been explained to the staff can be problematic, perhaps having an example or approximate necessary dose without having a strict protocol, so yes, having an idea of how to adjust perfusions would be good. A strict protocol would be more dangerous—I would be hesitant to apply a strict protocol, but would appreciate having an idea of the usual dosing range.</i></p> <p><i>A protocol [and] an additional nurse in these cases. Adding novel therapies adds to nurses' workload, and there is a lack of resources. One might say "as it is really a severe poisoning, the PC recommends to have an additional nurse." It is not just for the insulin, it is a really severe poisoning (...). It would make it easier to have an additional nurse for sure.</i></p>	15 (83%)
	Effect of past practices on the decision to initiate HIET when recommended by PC	<i>Yes, we do not do HIET often, but, when we do, it works, so the positive experiences encourage us to initiate it earlier.</i>	13 (72%)
	HIET considered as being standard of care	<p><i>I think it has been a standard of care for maybe 10 years. I don't remember a single patient intoxicated to CCB who wasn't treated with HIET.</i></p> <p><i>For us, yes, we also have pharmacists in the ICU, so when we have a CCB poisoning and the pharmacist suggests to get the kit, it has a positive influence. Interdisciplinary work helps, [e.g., the] nurses suggest starting insulin. Different professionals will suggest it, [such as] residents, etc. There are sufficient safety nets so that, even if a doctor decides not to start therapy, so many other professionals will speak up that it will be difficult to ignore.</i></p>	9 (50%)

could also facilitate the implementation of PC recommendations regarding the use of HIET.

Furthermore, the identified factors in this study could help PCs guide clinicians in nonacademic hospitals. By acknowledging and understanding the barriers reported in

academic centers, PCs can also help clinicians in community hospitals anticipate potential challenges related to using HIET. When clinicians are unfamiliar with the use of HIET, PCs should inform nurses that adequate time must be allocated to preparing this therapy and that obtaining reliable

Table 4 Beliefs limiting adherence to HIET

Domain	Belief by domain	Relevant sample quotes	Frequency of the belief (n = 18)
Knowledge	Strength of evidence supporting HIET	<i>There is no very good evidence, which could preclude its use. This does not influence my decision to use it or not, but [rather] influences the moment when I will use it. If it had better evidence, I would start it perhaps earlier, since I will do my standard things before, [such as] volume, vasopressors, inotropes, even glucagon if the patient is intubated before I start insulin (...).</i>	1 (6%)
	Tendency to use more vasopressors over initiating a HIET	<i>I tend to use vasopressors and if there is no improvement I use HIET.</i>	7 (39%)
Skills	Ease to proceed to HIET when it is indicated as compared with vasopressors	<i>It is not complicated, but there [are] a lot of emotions and perceptions from the [nurses]; they don't know the literature and it is sometimes a barrier.</i> <i>Uncertain—for me, it's easy; for the nurse, it's complicated. There are infusions to prepare, bags to change, blood glucose to monitor frequently. It is time-consuming for nurses, it is not easy but it is not difficult, and it is not without consequence.</i>	8 (44%)
	Impact on professional identity and autonomy when PC suggests to initiate HIET	<i>Sometimes, I don't agree [with] their recommendations completely, but you feel you have to follow them.</i>	2 (11%)
Belief about capabilities	Problems encountered while administering HIET	<i>It is mainly the management of the anxiety and uncertainty of the nurses on the use of insulin at nonstandard doses, especially when dealing with the risk of hypoglycemia and with nurses who are reluctant to measure blood glucose frequently.</i> <i>The measurement of BG (glucometer will not tell glycemia over certain levels). Initial bolus doses, people are uncomfortable to give those high doses. Education would help. We are in front of an unusual utilization of a well-known drug.</i> <i>It takes a lot of nursing time; it is not easy for an inexperienced nurse.</i>	9 (50%)
Goals	Other goals or priorities that interfere with HIET	<i>I will make sure that the patient is in the right place; I will start it when the patient is in the ICU (not on the ward or in the emergency department); I will make sure that the patient has the necessary catheters inserted under optimal conditions.</i> <i>To plan at the transfer to an ECMO center, but I would probably start HIET at the same time. Potentially, if the patient was hypoglycemic or severely hypokalemic, I would correct it before.</i>	4 (22%)
Memory, attention, and decision processes	Reasons influencing the decision to initiate HIET	<i>I know it's effective. Maybe with a cointoxication of hypoglycemics, but I would probably do it. I imagine that, with a small dose of vasopressors, I would not immediately start it but, with a patient who has significant vasopressor support, who had received calcium and had volume resuscitation, I would start it.</i> <i>If it is a mild intoxication and the patient answers to low-dose vasopressors, I wouldn't initiate it but, if it is severe, I don't have any barriers to use it.</i>	12 (67%)
Environmental context and resources	Effect of resource limitations on the decision to initiate HIET (e.g., staff, financial, time, or other)	<i>Problems of IV access, or other problems to address for the patient.</i> <i>Moreover, the glucometers complicate things a little. Otherwise, for the nurses, it's ok. Also, to find dextrose 50% can be difficult; it was a limiting factor the last time we initiated this therapy because it was unavailable at night... The fear of hypoglycemia is also quite limiting.</i> <i>No, in a university hospital, it is not a problem (...) In a community hospital, I don't think that they should keep these patients, they shouldn't call when they have four vasopressors and HIET. These patients should be transferred earlier to an ECMO-capable hospital. These patients are too sick for a small community hospital ICU.</i> <i>If I have four patients who are not doing well, the nurses are overwhelmed, and I cannot follow the blood glucose and apply the protocol safely, I will not do it.</i>	5 (28%)
Social influences	Opposition by other professionals or colleagues when initiating HIET	<i>There is apprehension by a colleague once in a while who hasn't seen a CCB intoxication for a while, but when you show the</i>	3 (17%)

Table 4 (continued)

Domain	Belief by domain	Relevant sample quotes	Frequency of the belief (n = 18)
Behavioral regulation	Consideration of PC treatment recommendations as standard of practice or as an option	<i>literature, it is fine. With nurses, it can be tough, they need to know what we are doing. It doesn't limit but takes a little more time to explain why and what we are doing. You need to realize that there is an issue and acknowledge the apprehension and explain that PCs consider that a priority and that we will explain how it works after. I give them the papers so they feel empowered, they are as much in charge of the patient [as] we [are].</i> <i>An option—an important option to consider—until there is better evidence.</i>	3 (17%)
	Impact of possible past practices inertia (before HIET was recommended)	<i>I still use vasopressors too long before initiating HIET sometimes. Yes, we use vasopressors all the time, HIET is a rare thing, so it is a factor; I might use more vasopressors and initiate HIET later because of that.</i>	7 (39%)
	Effect of past practices on the decision to initiate HIET when recommended by PC	<i>I am an old conservative who does not change his old habits. I never saw a significant positive effect, but I never had complications either, so I will continue to do it.</i>	1 (6%)

intravenous access is important. This could ensure that all resources are mobilized in time (i.e., an extra nurse, necessary consultants) and that an early transfer to a facility with a higher level of care can smoothly be made if necessary.

In light of the data collected via this study, the Quebec PC now systematically refers clinicians to the guidelines when suggesting the use of HIET. An example of how to wean an insulin drip is now offered to clinicians. A phone conference with the toxicologist is proposed earlier on to the clinician when the patient is unstable. Clinicians are encouraged to involve the pharmacist early on as well, particularly when HIET is used during the night, and are informed when the patient might need a significant increase in nurse workload

in order to plan for sufficient staffing. Also, the present study's results were presented to PC nurses and toxicologists to ensure that they were aware of potential barriers and facilitators.

Some of the clinicians who were interviewed for the present study came from the same hospitals, but this did not seem to limit the pertinence of collected information. For example, intensivists working in the same hospital did not report the same resource limitations: one reported the potential lack of nurses, another noted the difficulty of accessing a sufficient amount of dextrose 50% during the night, and a third stated that all necessary resources were available. Considering this, we do not perceive that the number of hospitals is a limitation to our study,

Table 5 Conflicting beliefs and beliefs unlikely to affect adherence to HIET

Domain	Beliefs by domain	Relevant sample quotes	Frequency of the belief (n = 18)
Goals	Presence of conflict between these treatment recommendations and other guidelines that need to be followed		Neutral for all participants
Optimism	Level of optimism or pessimism about the effects of HIET	<i>I'm pretty optimistic it's going to work; I guess this feeling encourages me to use it.</i> <i>On its effectiveness? Pessimistic. I was very optimistic about activated protein C, for tight glycemic control, but I learned that most things do not work when they are well-studied. Today, with reasonable evidence, there are experts who suggest it despite my pessimism. Who am I not to do it?</i>	11 (61%) positive 3 (17%) negative
Social influences	Interpersonal conflicts associated with the use of HIET		Neutral for all participants
Emotions	Effect of emotional response on the decision to initiate or not initiate HIET		Neutral for all participants

because different beliefs were reported by different intensivists working in the same hospital.

The timing of the publication of the consensus recommendations for the management of CCB poisoning [7] does not appear to us as having an effect on adherence to HIET, since local PC recommendations prior to the publishing of the guidelines already recommended HIET among first-line therapies.

There are many cases of tailored implementation strategies based on beliefs identified with the use of the TDF [40–43]. However, the evaluation of the effect of the designed interventions for most cases has either not been published or is underway [40]. At this time, there seems to be scarce evidence about the effectiveness of tailored implementation strategies, but such approach seems to be beneficial in increasing adherence according to studies that identified barriers and facilitators without the use of TDF [18, 19].

Our study has a number of limitations. First, the participants in this study all practiced in academic hospitals from two Canadian provinces and were relatively familiar with the use of HIET. We believe that the identification of realistic barriers and challenges encountered by clinicians using HIET necessitated the interview of physicians who have experienced or participated in its use. This reasoning is why we chose to interview physicians with critical care training who have been exposed to CCB-poisoned patients. As such, our findings may not be applicable to community hospitals or to other countries. Moreover, we did not evaluate beliefs perceived by other specialties, such as emergency physicians. Regardless, the difficulties that we report are difficulties that all clinicians could encounter. The intensivists interviewed in this study volunteered to participate, exposing our results to a potential selection bias. This could explain the high “*intention*” to adhere to HIET therapy. Clinicians refractory to PC recommendations might have been less inclined to participate, meaning that we might have missed important barriers to the implementation of HIET. Moreover, since this is a qualitative study, the results and the respective weight of identified beliefs on behavior are limited by the interpretation of the data collected. The use of a theory-based method might have limited the impact of this uncertainty. Furthermore, the answers obtained during interviews are subject to response bias that might limit the validity of the results.

Conclusion

This theory-based qualitative study identified several behavioral determinants that contribute both positively and negatively to clinician adherence to HIET. Our analysis will help identify potential domains to target for future multifaceted behavioral interventions, including a multidisciplinary

strategy to improve clinician adherence to HIET therapy applied for managing CCB poisoning [35, 44].

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Compliance with Ethical Standards

Conflicts of Interest None.

Appendix 1

Interview questions for intensivists

This is a semistructured interview with the purpose of identifying barriers and facilitators to adherence to PCC treatment recommendations for patients with a calcium channel blocker intoxication. By answering these questions, we consider that you consent to the recording of your answers and their use for research purposes. All information will be kept confidential and no nominal information will be kept.

Use of HIET

What place do you perceive your PCC protocol suggests for the use of HIET?

How does the strength of the evidence behind HIET influence your decision to use it?

Do you tend to use more vasopressors or to initiate a HIET?

What reasons would limit you to initiate a HIET?

Does the knowledge behind the mechanism of action and the reasons why it is recommended have an influence on your decision to initiate HIET?

How confident are you about proceeding to a HIET and the potential technical difficulties?

How is it easy or complicated for you to proceed to a HIET?

How does the credibility you give to your PCC influence your decision to initiate HIET if suggested by the PCC?

What is the impact on your perception of your professional identity and autonomy when PCC suggests to initiate HIET?

What problems have you encountered while doing it?

What could help you to do a HIET?

What is your level of optimism or pessimism about the effects of a HIET?

What do you think could happen if you do not use a HIET (for example if you only use pressors)?

How does the risk–benefit of a HIET influence your decision to initiate it?

What incentives are there for you to initiate a HIET?

What is your level of motivation to initiate a HIET when you have a CCB-poisoned patient?

What other goals could interfere with the HIET? What is your priority?

Is there any conflict between these treatment recommendations and other guidelines that you need to follow? How does it influence your decision to initiate a HIET?

Is HIET something you usually do?

How is it intuitive for you to consider a HIET when you have a patient with CCB poisoning?

What reasons could make you decide not to do a HIET when it is recommended by the PCC?

How do other tasks requesting your attention limit you to initiate a HIET with a patient with significant CCB poisoning?

How does CCP recommendations to initiate a HIET influence your decision-making process?

How do resources limitations influence your decision to initiate a HIET (staff, financial, time, or other)?

Are the resources necessary to do a HIET accessible when needed?

Have you seen colleagues use a HIET? Does it influences your decision to use it?

Do you perceive opposition by other professionals or colleagues when you want to initiate a HIET? How does it influence your decision to initiate it?

Does using a HIET ever brought you interpersonal conflicts?

Are treatment recommendations from the PCC a practice standard, an option, an opinion, a norm?

What emotional response do you have while initiating HIET (apprehension, anxiety, worry?)

How does this emotional response affect your decision to initiate or not a HIET?

What preliminary steps appear essential to you before you initiate a HIET (personal or structural etc.)

Are there processes or strategies that you think would facilitate the application of a HIET?

Do you receive any feedback or follow-up on your CCB-poisoned patients when PCC recommends to initiate a HIET?

How much does your ease with therapeutic options that were used before the arrival of HIE influence your decision to initiate a HIE?

What effect does your past practice have on your decision to initiate a HIE when it is recommended by PCC?

Do you think physicians consider or will consider HIE as a standard treatment? If not will it become a standard? Will it be long?

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