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Research article

Differences in clinical manifestations between cases stung by single-tentacle and multiple-tentacle box jellyfish over two decades

Lakkana Thaikruea

Department of Community Medicine, Faculty of Medicine, Chiang Mai University, Chiang Mai 50200, Thailand

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ABSTRACT

There are no routine laboratory investigations to identify jellyfish species and toxins in Thailand. Distinguishing clinical manifestation is important for medical care and also recommendations for the population. This study aimed to describe the clinical manifestations of box jellyfish stinging cases and determine differences between cases stung by single- (SBJ) and multiple-tentacle box jellyfish (MBJ). This retrospective study was conducted in Thailand. Data regarding injuries and deaths eligible for inclusion were those pertinent to stinging by box jellyfish under the National Surveillance System of Injuries and Deaths Caused by Toxic Jellyfish. All cases detected by the Toxic Jellyfish Networks were investigated. There were 29 SBJ, 92 MBJ, and 3 SBJ/or MBJ cases in the period 1999 to 2021. In about half of the cases in each group had abnormal heart rates and about one-third had respiratory distress. The SBJ group had a high proportion of pain in the other parts of the body (38.2%), abdominal cramps (13.8%), fatigue (24.1%), anxiety/agitation (24.1%), and there was no death. The MBJ group had a high proportion of severe pain and severe burning pain at the site of the wounds (44.3%), swelling/edema at the affected organs/areas (46.8%), collapse/near-collapse (30.4%), worse outcomes (9.8%), and 9.8% deaths. In comparison to the MBJ group, the SBJ group were 13.4 times (95% Confidence Intervals of Relative Risk: 4.9, 36.6) and 6.1 times (1.2, 31.4) more likely to have pain in other parts of the body and abdominal cramps, subsequently. MBJ group was 1.8 times (1.4, 2.2) more likely to have pain at wounds than the SBJ group. Some initial symptoms might make health professionals misdiagnose SBJ as MBJ stinging. The Irukandji-like syndrome that appeared later among SBJ cases is the clue for correct diagnosis. These results are useful for the improvement of diagnosis, medical care, and surveillance.

1. Introduction

[1]Envenomation by cnidaria can result in cytotoxic, cytolytic, hemolytic, dermonecrotic, and neurotoxic effects [1,2]. In Thailand multiple-tentacle (MBJ) and single-tentacle box jellyfish (SBJ) stings are the major health problems in the area of marine animal envenomation [3–7]. *Chironex* spp. is one of the most lethal MBJ [1,3,5,7–9]. Irukandji syndrome and Irukandji–like syndrome are caused by SBJ stings. Carybdeid jellyfish that were identified include *Carukia barnesi, Morbakka* spp., and *Morbakka fenneri* [10–12]. Thaikruea L. reported Irukandji–like syndrome cases caused by box jellyfish found in Thailand [12] Different species of SBJ have been

E-mail address: lakkana.t@cmu.ac.th.

[1] SBJ single-tentacle box jellyfish. MBJ multiple-tentacle box jellyfish.

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shown to cause Irukandji-like syndrome with different clinical manifestations. However, little is still known about the various species [1,5,12,13].

Although both SBJ and MBJ are in the same class of Cubozoan in the phylum Cnidarians, their envenomation is not quite the same [1,14–18]. The envenomation by lethal MBJ, particularly *Chironex* spp., causes predominantly immediate effects, while SBJ takes 5–40 min for symptoms to develop. Based on study by D'Ambra et al., *Chironex fleckeri* (MBJ) had lethal cardiotoxic, dermatonecrotic, cytoloxic, and hemolytic symptoms, while *Carukia banersi* (SBJ) had cytolytic, hemolytic, and neurotoxic symptoms. There is limited knowledge regarding toxic peptides in cnidarian toxins and there is significant divergence in their structure [1]. However, toxins from SBJ such as *Morbakka* spp. can cause immediate effects [5,11,12,14,18]. To date, there are no routine laboratory investigations to identify species and toxins in Thailand. Furthermore, only a few resident training programs include some contents regarding box jellyfish envenomation. Distinguishing between the different clinical manifestations is important for diagnosis, medical care, surveillance, and prevention. Information from injuries and deaths caused by both SBJ and MBJ is valuable evidence in collating practical guidelines and policy implementation. The aim of this study was to describe the clinical manifestations of box jellyfish stinging cases and determine the main differences in the clinical manifestations between cases stung by SBJ and MBJ.

2. Materials and methods

2.1. Study design and setting

In 2008, Dr. Siriarayapon (The Epidemiology Division, Department of Disease Control, Ministry of Public Health; DOE) and Prof. Dr. Thaikruea (The Faculty of Medicine, Chiang Mai University) determined that rapid response from community members was critical if lethal species of jellyfish envenomation could result in death within 2–10 min. These two professionals formed the lead team and recruited a task force. The lead team began to establish ad hoc surveillance in order to detect suspected cases stung by toxic jellyfish and accumulate knowledge. This team improved the ad hoc surveillance by increasing case detection and establishing three toxic jellyfish networks, namely a task force, an expert team, and a community group. This ad hoc surveillance system was then integrated into the National Surveillance System of the Ministry of Public Health. To reduce false warnings about toxic jellyfish sightings and stings the lead team and marine biology experts served as core members of all networks to rapidly verify incidences involving toxic jellyfish from the first step of notification. The lead team cooperated with marine biologists and ecologists mainly from the Marine and Coastal Resources Division of the Ministry of Natural Resources and the Environment and international health experts (the majority of which were Australian). Events were investigated by verifying whether the jellyfish sting reported by the networks were health threatening or toxic. The surveillance system of injuries and deaths caused by toxic jellyfish took into account a combination of active, passive, event-based, indicator-based, and community-based surveillance. The early warning element had multi-stakeholder participation, the combination of a bottom up approach and the top down role of authorization and expertise strengthened the capabilities for early warning by reducing cases of false warnings, providing risk communication, and incorporating a rapid response. The detection has been improved since the system was established. From 2008 to 2021, the surveillance system of toxic jellyfish cases/deaths in Thailand was under the responsibility of the DOE [4,6]. However, in 2022, it moved to be under the responsibility of the Division of Injury Prevention, Department of Disease Control, Ministry of Public Health. The system is still in the process of development (April 2023). This retrospective study was conducted in Thailand. Data regarding injuries and deaths eligible for inclusion were those pertinent to stinging by box jellyfish under the National Surveillance System of Injuries and Deaths Caused by Toxic Jellyfish. All cases detected by the Toxic Jellyfish Networks were investigated [4,6,7]. The investigation was under the government service policy of emergency and public health threats.

2.2. Case selection

All reported cases of box jellyfish stings from 1999 to 2021 in Thailand were included. Data collection included demographic (age, gender, occupation, and nationality), details of the incident, description of clinical manifestations, treatment outcome, and photographs of the affected areas.

2.3. Data analysis

Descriptive analysis included proportion (percentage), median (range), and mean (±standard deviation), depending on data distribution. The univariate analysis included the Chi-square test or Mid-P exact tests depending on the expected value (less than 5). The alpha level was 0.05. Risk Ratio and 95% Confidence Intervals (RR and 95% CI) were used to determine the statistical difference between toxic jellyfish groups.

2.4. Ethics

The review and approval by the Research Ethics Committee of the Faculty of Medicine, Chiang Mai University were waived for this study due to the secondary nature of the data (No. Exemption 8072/2021 of Study code: COM-2564-08072/Research ID: 8072 on May 11, 2021). Consent forms of all human images were obtained.

3. Results

3.1. Demographics of box jellyfish envenomation cases

One hundred and twenty-four cases of stinging by box jellyfish during the period from 1999 to 2021 were included. There were 29 SBJ, 92 MBJ, and 3 SBJ/or MBJ cases. The median age was 25.0 years (range 1.8–68.0 years). The sex ratio of male to female was 1.2: 1. The majority of cases were tourists (69.1%) and Thai nationals (48.7%). The three years with highest incidence cases were 2017 (22.6%), 2019 (15.3%), and 2016 (14.5%)(Table 1). The three months with the highest incidence were August (19.8%), October (14.9%), and September (14.0%) (Table 1). The majority of cases were stung by MBJ (74.2%) (Table 1). The five provinces with the highest incidence were Surat Thani (54.0%), Krabi (11.3%), Trat (11.3%), Phetchaburi (7.3%), and Trang (5.7%) (Fig. 1). Other provinces with stinging incidents included Rayong (3.2%), Stun (2.4%), Phuket (1.6%), Chonburi (1.6%), Prachuap Khiri Khan (0.8%), and Songkla (0.8%) (Fig. 1).

3.2. Description of incidences

There were 124 incidences of jellyfish stinging, the distribution of events as follows: during activities in the sea (swimming/walking/playing/standing/feeding dugong/installing fishnet/catching fish or squid) at times of potential risk (evening/night time/and during or after rain) 43.5%, activities in the sea (swimming/walking/playing/standing/installing seine) without potential risk 41.3%, during other activities (cooking MBJ/eating MBJ/rescuing cases involving stinging by box jellyfish without protection/taking off wetsuit) 7.2%, and unknown 8.0%.

There was often more than one area of the body affected in each case. The total numbers of areas on the body affected among the 124 cases were 215. The top five most common areas were the lower extremities 33.0%, upper extremities 22.3%, hand/wrist 12.1%, ankle/foot 8.8%, and head/neck 5.6%.

3.3. Description of clinical manifestations

The majority of the cases had tentacle marks that appeared similar to caterpillar track of a tank (caterpillar track-like rash), which had a frequency of 97.7% in the MBJ group and 89.7% in the SBJ group as shown in Figs. 2 and 3. A high proportion of swelling/edema occurred at the affected areas/organs in the MBJ group (Table 2) as shown in Fig. 4.

With regard to pain characteristics, one case without pain and two cases without pain data in the MBJ group were excluded from the analysis. One case without pain was in the MBJ group. This case involved eating one small match-head size box jellyfish in a spicy salad. The two categories of the characteristics of pain were pain at the site of the wound and pain at the other parts of the body (Table 2). Each case could present with more than one type of pain, therefore, there were 76, 140, and 3 types of pain in the SBJ, MBJ, and SBJ/or MBJ groups, respectively (Table 2). With regard to pain at the site of the wound, 50% of pain types in SBJ and 87.8% of pain types in MBJ groups were pain and burning pain types, respectively. The majority of pain and burning pain levels were severe and there was a higher percentage in the MBJ group (44.3%) than those in the SBJ group (25.0%) (Table 2). Pain in other parts of the body occurred in 38.2% of cases in the cases of stinging by SBJ and 2.8% of cases stung by MBJ (Table 2).

Table 1
Description of cases involving box jellyfish stings by time and group.

Description (n = 124)	Frequency n	Percentage %
Year of incident		
1999–2008	9	7.3
2010–2015	32	25.8
2016–2021	83	66.9
Month of incident[a]		
January	2	1.7
February	1	0.8
March	6	5.0
April	4	3.3
May	8	6.6
June	16	13.2
July	10	8.3
August	24	19.8
September	17	14.0
October	18	14.9
November	5	4.1
December	10	8.3
Box jellyfish		
Multiple-tentacle	92	74.2
Single-tentacle	29	23.4
Multiple or single-tentacle	3	2.4

[a] Excluded 3 missing records.

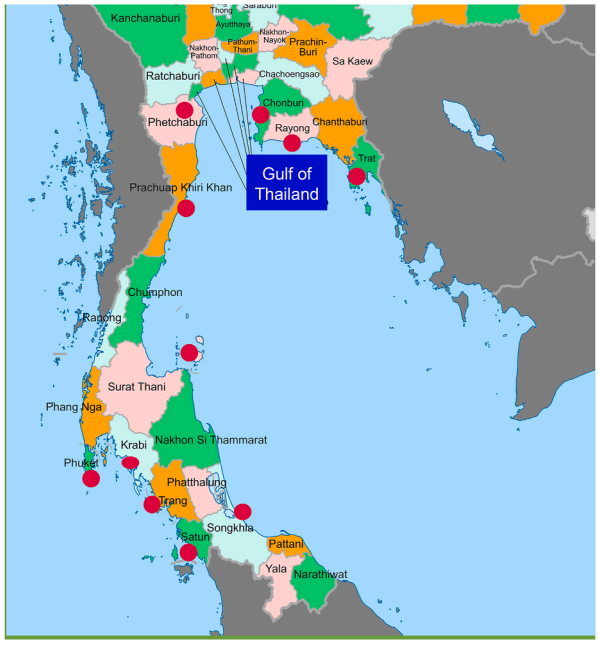

Fig. 1. Figure 1 Box jellyfish stings by province in southern Thailand, 1999–2021.

Fig. 2. Caterpillar track-like rashes caused by single-tentacle box jellyfish stings.

In the SBJ group, there was a high proportion of fatigue (24.1%), anxiety/agitation (24.1%), and abdominal cramps (13.8%) (Table 2). In the MBJ group, there was a high proportion of collapse/near-collapse (30.4%) (Table 2). About half and, one-third of cases in each group had an abnormal heart rate (irregular/increased/no heartbeat) and respiratory distress (Table 2).

The majority of cases involving stinging by SBJ had improved outcomes and only two were classed as worse (Table 2). One case experienced a wave of severe back pain that did not improve after receiving morphine injections and needed referral to another hospital. Another case had pain in the arms. This case had swollen arms after being discharged and returned to the emergency room with high blood pressure and wheezing. About one-fifth of cases stung by MBJ were classified as worse/referral/death (Table 2). The

Fig. 3. Caterpillar track-like rashes caused by multiple-tentacle box jellyfish stings.

nine worse cases involving sting by MBJ were: one case had wound gangrene and infection; one case had pneumonia and a decreasing hematocrit and low platelets; one case had wound gangrene and infection and required sutures; one case had a wound gangrene and infection and required surgery resulting in 91 stitches sutured; one case had muscle necrosis and digital gangrene and necessitated distal amputation of the right distal index finger and thumb; one case had severe inflammation at the site of the wounds and unconsciousness; one case had a painful progressively swollen arm for at least three weeks with numb feeling in the neck and had infection; one case had progressive face swelling and could not open eyes after being discharged and returned to hospital for further treatment in the in-patient ward; and one case had chronic effects for almost two years, including severe pain at the site of the open wounds, swelling in the right ankle, gangrenous wounds, infected wounds, itching scars, hyper sensation of the leg, anaphylactic shock, difficulty walking, and arrhythmia (ventricular extrasystole and subventricular tachycardia).

3.4. Different clinical manifestations between single-tentacle and multiple-tentacle box jellyfish stings

Cases involving stinging by SBJ had a significant incidence of high blood pressure (61.9%) while cases involving stinging by MBJ had normal and non-measurable blood pressure (p-value 0.042). Cases stung by SBJ were 0.6 time (95% CI of RR: 0.5, 0.7) less likely to have pain at the site of the wounds (or MBJ cases were 1.8 times (1.4, 2.2) more likely to have pain at the site of the wounds) and 0.4 time less likely to experienced collapse/near-collapse than cases stung by MBJ, statistically significant incidences (Table 3). Cases involving stinging by SBJ were 13.4 times (4.9, 36.6) more likely to have pain in other parts of the body and 6.1 times (1.2, 31.4) more likely to have abdominal cramp than cases stung by MBJ. These were also statistically significant (Table 3).

4. Discussions

The majority of lethal box jellyfish stings in Thailand involved MBJ [4–7,19]. This study found that the incidence rates were highest from 2016 to 2019. Some of the reasons for this are: a misdiagnosis and underreporting in earlier years, the later establishment of surveillance systems and networks, more training and available guidelines in recent years, and jellyfish bloom [4,6,20,21]. The incidence rates were low during 2020 and 2021. The main reason was the Covid-2019 pandemic and the Thai government implemented rigorous prevention and control programs that affected tourism [22,23]. When Thailand re-opened for tourism in 2022, number of incidents increased. With regard to seasonal variation, the incidence was high from June to October, the majority of cases occurring in the Surat Thani Province in the Gulf of Thailand during the high season for tourism, as the probability of contact between jellyfish and tourists increased [7,23,24]. It is worth noting that nearly half of the cases occurred during activities in the sea at times of potential risk. These potential risks included activities in the sea in the evening or night-time and during or after rain. These findings contributed to recommendations for safe tourism in Thailand by Thaikruea L. and the task forces [4,6,25,26].

There was often more than one area of the body affected, however the most common area was the lower extremity. This outcome was particularly related to MBJ stings in shallow water [15]. Cnidaria envenomation has many effects, including cytotoxic, cytolytic, hemolytic, dermonecrotic, and neurotoxic. Clinical manifestations in this study were relelated to these effects [1,2,14]. Children stung by SBJ, they could present with nausea, vomiting, and abdominal pain. These clinical presentations might be confused by health personnel and misdiagnosed as appendicitis, particularly among the cases with small tentacle marks or they were unaware that the patient has been stung by jellyfish [5].

This study found main differences in the pain experiences which provide important information for differential diagnosis. The author's experience, health professionals have rarely described them clearly in the past. Cases in the MBJ group were more likely to have pain at the site of the wound and were less likely to have pain in other parts of the body than cases in the SBJ group. The characteristics of pain in the SBJ group were relevant to the systemic reaction of Irukandji or Irukandji-like syndrome [12,15,16,18,27,28]. Single-tentacle box jellyfish stinging can cause Irukandji syndrome and Irukandji –like syndrome. In 1964, Barnes et al. reported *Carukia barnesi* as the major cause of Irukandji syndrome [29]. The definition of Irukandji syndrome is presence of a severe local and systemic reaction occurring after a *Carukia barnesi* box jellyfish sting involving contact with the skin [29]. The clinical manifestation

Table 2
Clinical manifestations of cases by box jellyfish groups.

Clinical manifestation[a]	Single-tentacle Incident/n (%)	Multiple-tentacle Incident/n (%)	Single/or Multiple-tentacle Incident/n (%)
Swelling/edema at affected areas/organs			
Present	8 (27.6)	37 (46.8)	1 (33.3)
Absent	21 (72.4)	42 (53.2)	2 (66.7)
Pain at the site of the wounds			
Burning-mild to moderate	16 (21.1)	38 (27.1)	1 (33.3)
Burning-severe	6 (7.9)	30 (21.4)	0
Pain-mild to moderate	3 (3.9)	23 (16.4)	2 (66.7)
Pain-severe	13 (17.1)	32 (22.9)	0
Electric shock	2 (2.6)	2 (1.4)	0
Itching/irritation-mild to moderate	1 (1.3)	17 (12.1)	0
Itching/irritate-severe	0	3 (2.1)	0
Numbness in affected area	1 (1.3)	5 (3.6)	0
Long term hypersensitivity	1 (1.3)	1 (0.7)	0
Pain in other parts of the body			
Abdominal pain	1 (1.3)	0	0
Back pain	4 (5.3)	0	0
Leg pain	1 (1.3)	1 (0.7)	0
Bone pain	1 (1.3)	0	0
Body ache	4 (5.3)	0	0
Muscle pain	2 (2.6)	0	0
Chest pain-mild to moderate	2 (2.6)	1 (0.7)	0
Chest pain-severe	1 (1.3)	1 (0.7)	0
Heart pain	2 (2.6)	1 (0.7)	0
Heart pain -similar to electric shock	1 (1.3)	0	0
Transfer of pain to other areas	4 (5.3)	0	0
Wave of pain/increased pain	4 (5.3)	0	0
Recurrent shooting pain	1 (1.3)	0	0
Recurring leg pain with altered sensation on shins	1 (1.3)	0	0
Fatigue			
Present	7 (24.1)	14 (16.7)	0
Absent	22 (75.9)	70 (83.3)	3 (100.0)
Anxiety/Agitation			
Present	7 (25.0)	9 (11.25)	0
Absent	21 (75.0)	71 (88.75)	3 (100.0)
Nausea/vomiting			
Nausea	0	4 (4.6)	0
Vomiting	3 (10.3)	4 (4.6)	0
Absent	26 (89.7)	79 (90.8)	3 (100.0)
Abdominal cramp			
Present	4 (13.8)	2 (2.3)	0
Absent	25 (86.2)	86 (96.6)	3 (100.0)
Blood pressure			
High	13 (61.9)	29 (37.2)	0
Not high	8 (38.1)	35 (44.8)	2 (100.0)
Non-measurable	0	14 (18.0)	0
Irregular/increased heartbeat			
Present	12 (50.0)	30 (36.1)	0
Absent	12 (50.0)	39 (47.6)	3 (100.0)
No heartbeat	0	14 (17.1)	0
Respiratory distress			
Present	9 (32.2)	28 (31.2)	1 (33.3)
Absent	19 (67.8)	61 (67.8)	2 (66.7)
Collapse/near-collapse			
Present	3 (11.5)	28 (30.4)	0
Absent	23 (89.5)	64 (69.6)	3 (100.0)
Outcome after stinging			
Improved	27 (93.1)	74 (80.4)	3 (100.0)
Worse/Referral	2 (6.9)	9 (9.8)	0
Died	0	9 (9.8)	0

[a] Swelling/edema: Excluded 13 non-applicable. Wounds: One case without pain and two cases without pain data were excluded. Fatigue: Excluded seven non-applicable and one missing data. Anxiety/Agitation: Excluded eleven non-applicable and two missing data. Nausea/vomiting: Excluded one non-applicable and three missing data. Abdominal cramps: Excluded one non-applicable and two missing data. Blood Pressure: Excluded eight non-applicable and fifteen missing data. Irregular/increased heartbeat: Excluded three non-applicable and eleven missing data. Respiratory distress: Excluded one non-applicable. Collapse/near-collapse: Excluded three non-applicable.

Fig. 4. Swelling of affected organs among multiple-tentacle box jellyfish stings.

Table 3
Different clinical manifestations between single- and multiple-tentacle box jellyfish stings.

Clinical manifestations[a]	Single-tentacle Incident/n (%)	Multiple-tentacle Incident/n (%)	Relative Risk (95% Confidence Intervals) p-value[b]
Blood pressure			
High	13 (61.9)	29 (37.2)	0.042
Not high	8 (38.1)	35 (44.8)	
Non-measurable	0	14 (18.0)	
Irregular/increased heartbeat			
Present	12 (50.0)	30 (36.1)	0.082
Absent	12 (50.0)	39 (47.6)	
No heartbeat	0	14 (17.1)	
Respiratory distress			1.0 (0.5, 2.0)
Present	9 (32.2)	28 (31.2)	0.994
Absent	19 (67.8)	61 (67.8)	
Pain at the site of the wounds			
Present	38/76 (50.0)	123/140 (87.8)	0.6 (0.5, 0.7)
Absent	38/76 (50.0)	17/140 (12.2)	<0.001
Pain in other parts of the body			
Present	29/76 (1.3)	4/140 (2.9)	13.4 (4.9, 36.6)
Absent	47/76 (5.3)	136/140 (97.1)	<0.001
Abdominal cramps			
Present	4 (13.8)	2 (2.3)	6.1 (1.2, 31.4)
Absent	25 (86.2)	86 (96.6)	0.036[c]
Collapse/near-collapse			
Present	3 (11.5)	28 (30.4)	0.4 (0.1, 1.1)
Absent	23 (89.5)	64 (69.6)	0.053

[a] Wounds: One case without pain and two cases without pain data were excluded. Abdominal cramp: Excluded one non-applicable and two missing data. Collapse/near-collapse: Excluded three non-applicable.
[b] Statistically significant when p-value equal or less than 0.05.
[c] Mid-P exact test.

developed between 5 and 40 min after being stung, symptoms predominantly being pain and autonomic disturbance (i.e. severe muscle pain, muscle cramps, vomiting, hypertension, heart failure sweating, and agitation) [12,15,18,30]. The term Irukandji –like syndrome was often used when the incident took place outside Australia, and was as a result of stinging by other species (not *Carukia barnesi*), and some symptoms or signs differed from the classic Irukandji syndrome (i.e. severe pain at the wound site with an immediate systemic reaction, loss of consciousness within 5 min, etc.) [12]. In the cases involving stinging by *Morbakka* spp. (large size SBJ) and some unidentified species found in Thailand there was immediate severe pain or severe burning pain at the wound site and near collapse [12]. These initial symptoms might cause health professionals to misdiagnose the condition as attributable to stinging by MBJ. The Irukandji-like syndrome that appears later on among SBJ cases is the clue for correct diagnosis [12,15,16,18,31]. In the SBJ group, there was a high proportion of fatigue and anxiety/agitation, whereas in the MBJ group the percentage of collapse/near-collapse was high. These findings were relevant to the envenomation of SBJ and MBJ [1,7,9,15,16,19,28,31]. In Thailand cases involving stinging by MBJ had more severe clinical manifestations than those involving SBJ. Cases experienced immediate severe pain or severe burning pain at the site of the wounds and about one-third collapsed or were at a point of near-collapse. Almost one-fifth had non-measurable blood pressure and no heartbeat and only five cases survived after receiving cardiopulmonary resuscitation; whereas none of the cases stung by SBJ died. Possible explanations were a high volume of toxins (higher numbers of tentacles and larger contact areas), different species with a more potent toxin, or differences in the health conditions of the cases [1,5,9,16,19,25,27,28,31]. The fatal cases lost conscious, stopped breathing, had no pulse and required resuscitation at the scene. For those who received inappropriate first aid that resulted in increased nematocyst firing (i.e. rubbing with sand, washed in fresh water, and use of an ice pack) often died before arrival of the health services. The probability of death was high if the affected areas were more than 50%. Thus, the potential cause of death might be the high dose of toxins, specifically those with cardiotoxic, neurotoxic, cytotoxic, and hemolytic effects. Based on study by D'Ambra et al., *Chironex fleckeri* (MBJ) had lethal cardiotoxic, dermatonecrotic, cytoloxic, and hemolytic effects, while *Carukia banersi* (SBJ) had cytolytic, hemolytic, and neurotoxic effects. The toxic structures show significant divergence [1]. There was a higher incidence of worse outcomes in the MBJ group than those in the SBJ [1,5,7,15,16,19,32]. Only two worse outcomes occurred in the SBJ group. One case had a wave of severe back pain that did not improve after receiving morphine injections and was finally referred to another hospital. This case received inappropriate first aid that stimulated more nematocyst firing (rubbing during pouring of vinegar for less than 30 s) [1,12]. Another case had pain in the arms with associated swelling after being discharged from the hospital and returned to the emergency room with high blood pressure. This case had a history of hypertension as an underlying disease and also received inappropriate first aid (fresh water and scrubbing with soap) [1,12]. The cases with worse outcomes had excruciating pain and went through long-term treatments including, curettage, surgery, suturing, and distal amputation. Other studies also report high mortality of victims stung by MBJ [3,30,33,34]. A study in hospitals in Australia found that box jellyfish caused about 70% of cases involving envenomation but there were no fatal cases [34]. The potential reason for this difference was that cases in this Australian study were less severe than cases in this study. In the context of this study in Thailand, not all cases stung by box jellyfish went to health centers or hospitals. People with mild injuries might seek help from the drug store or treat themselves using herb remedies. Furthermore, health personnel lacked knowledge as this aspect of medicine is not officially included in the curriculum, and the surveillance system of toxic jellyfish was also newly established as ad-hoc in the earlier years. Therefore, the stinging by box jellyfish might be misdiagnosed and underreported, particularly in the case of mild injuries. Data related to irregular/abnormal heartbeat and respiratory distress showed no statistically significantly differences between groups but knowledge related to these is biologically important for medical care. Cases involving stinging by SBJ often had high blood pressure initially which slowly decreased to normal or low levels. Whereas cases involving stinging by MBJ usually had high blood pressure due to pain and the readings decrease dramatically after receiving morphine injection. Therefore, one recommendation from Thaikruea L. and the task forces is the monitoring of vital sign [12,25,26]. The caterpillar track-like rash is an important sign in enabling a differential diagnosis with regard to other toxic jellyfish stings.

The main limitations of this study were missing data and few cases had no images of the lesions available, both these were relatively low. The limitations did not affect the findings when it came to of comparing the clinical manifestations because the missing data only involved three cases preventing confident identification of the group of box jellyfish. The advantages of this study are a large number of cases were included with reliable information. The trained personnel from the toxic jellyfish networks under the national surveillance system verified and investigated the cases to ensure the accuracy of the information [4,6,7,19].

5. Conclusions

The MBJ group had a high percentage of swelling/edema at the site of the affected organs/areas, and a high incidence of collapse/near-collapse, and worse outcomes. Compared to cases stung by SBJ, the MBJ cases were less likely to experience pain in other parts of the body and abdominal cramp but were more likely to have pain at the site of the wounds and experience collapse/near-collapse. One-tenth of the MBJ group died but there were no death in the SBJ group. The cases involving sting by *Morbakka* spp. which occurred in Thailand had immediate severe pain or severe burning pain at the sites of the wounds and almost collapsed. These initial symptoms might make health professionals misdiagnose the condition as MBJ stinging. The Irukandji-like syndrome that appeared later on among SBJ cases is the clue for correct diagnosis. Data related to irregular/abnormal heartbeat and respiratory distress showed no statistically significantly differences between groups but knowledge related to these is biologically important for medical care. The caterpillar track-like rash is an important sign in establishing a differential diagnosis with other toxic jellyfish stingings. The results of this study are useful for the improvement of diagnosis, medical care, surveillance, and prevention programs.

Author contribution statement

Lakkana Thaikruea: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; and Wrote the paper.

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Declaration of competing interest

The authors 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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