Fatal and Non-Fatal Stingray Envenomation

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ABSTRACT

A fatality occurred in a previously healthy 12-year-old boy after a penetrating chest injury from a stingray barb. The injury occurred under freak circumstances. Death was a result of cardiac tamponade, which was secondary to venom-induced, localized myocardial necrosis and spontaneous perforation, six days after the direct penetration of the right ventricle by the barb. Three other cases of less serious stingray envenomation are described which illustrate the significant localized morbidity that may occur without immediate wound exploration and toilet after adequate anaesthesia. We also report a study of a series of 100 minor stingray envenomations which, when treated, resulted in no morbidity. It is possible that local infiltration with 1% plain lignocaine may have a direct counteraction against stingray venom that remains in the wound area. Stingray venom has insidious, but powerful, localized tissue necrosing properties in humans.

INTRODUCTION

Several earlier, reports of stingray injuries can be found in the literature. The tail of the stingray contains at least one serrated spine, and envenomation by these may result in either jagged lacerations or simple puncture wounds only. When the integumentary sheath on the barb ruptures, venom may be released into the tissue of the victim causing severe localized pain. This occurred in 75 % of the cases that were reported in one study.' When proven stingray wounds are not painful, it is because either the integumentary sheath of the stingray has been ruptured previously and, hence, venom has not been released, or the integumentary sheath has not penetrated or ruptured.

Several unusual cases of stingray envenomation have involved penetration of the barb into the abdominal or thoracic cavities of their victims resulting in significant morbidity. Previously, six deaths have been attributed to this type of injury. Three of these cases are well-documented and two cases include identification of the stingray. One death was reported as being caused by stingray envenomation but was not documented fully;' and another death which was reported in the same article was a result of tetanus six days after envenomation. The sixth death, the only previously reported fatal Australian case, was attributed at autopsy to stingray barb penetration of the heart, although the actual aggressor was not seen.'

We report a delayed fatality in a 12-year-old boy after a freak accident. Three other cases are presented to emphasize that significant morbidity may occur unless the wound is cleaned carefully as soon as possible, removing any venom and remaining integumentary sheath.

Clinical records

Case 1

On April 29, 1988, a warm calm day in Mackay, north Queensland, a 56-year old man was walking across a sand flat in about 30 cm of sea-water while on a fishing expedition. He was wearing rubber boots and long trousers. He had seen a number of stingrays in the water, but suddenly one moved out quickly from under his feet and he felt instantaneous pain in his right ankle.

When he reached the shore and removed his boots, he found a small blood stained puncture mark just below, and slightly in front of, his right lateral malleolus. As it was very painful, he attended a general practitioner's surgery where he received an intramuscular injection of morphine (10 mg) and metoclopramide (10 mg). The pain settled very quickly. The wound was covered with a sterile, non-stick dressing.

The wound remained uncomfortable although no further medical attention was sought until a week later when it and the surrounding area became hot, red and painful. A swab was taken for microbiological culture and antibiotic sensitivity testing and the patient received an intramuscular injection of lincomycin (300 mg) and a tetanus toxoid booster. He returned home and commenced to receive clindamycin (300 mg by mouth, three times a day). He was advised to elevate and rest the limb and to apply ice-packs to alleviate the swelling. *Citrobacterfreundii,* which was sensitive to most common antibiotic agents, including clindamycin, was cultured from the swab.

During the next seven months, the wound became reinfected on a number of occasions, which included one episode of osteomyelitis. As well as systemic antibiotic treatment, on three separate occasions the wound area had to be excised widely after local anaesthesia to encourage healing by granulation. One occasion, the excised tissue was sent for pathological examination and was reported as:

> *Sections show acute and chronic inflammatory reaction. Particles of exogenous material can be seen deep in the dermis, which also shows evidence of hypertrophic scarring. Interpretation: foreign body reaction*.

The osteomyelitis was apparent as a chronically discharging sinus; at this stage, x-ray examination of the patient's foot confirmed a small lytic area, about 1 min in diameter, on the lateral calcaneum. He was admitted to hospital on September 5, 1988 and was treated with bed rest and intravenously administered gentamicin (80 ring, every eight hours) and cloxacillin (500 mg, every six hours) for five days. Wound cultures grew *Haemophilus parahaemolyticus* and *Enterobacter sakazakii* which both were sensitive to the prescribed antibiotic agents. On other occasions, the wound culture grew *Enterobacter cloacae, Staphylococcus aureus, Vibrio parahaemolyticus, Pseudomonas aeruginosa* and *Acinetobacter anitratum.*

Four months after the original envenomation, a small amount of material that resembled glass was extruded from the skin just below the original wound area. Another similar, small raised area below and nearer the sole of the foot was explored carefully with a needle and an operating microscope. This produced more, similar fragments, which were identified microscopically by one of us (P. J. F.) as parts of a stingray barb. Eighteen months after envenomation, the area is scarred but healed, although the ankle still swells and becomes painful when the limb is immobile for any length of time.

Case 2
A 26-year-old man was walking through shallow water in a mangrove swamp on November 11, 1988, when he felt pain in his left leg. He saw nothing in the water and thought that he had caught his leg on a mangrove root. However, the area became quite painful and when he left the water he noticed a small deep gash in his leg just above his ankle. No foreign material was obvious on casual observation.

As the pain persisted he went to the local hospital, although it took him several hours to reach there. The wound was cleaned and butterfly dressings were used to approximate the wound edges. Tetanus toxoid was administered intramuscularly and he commenced to receive metronidazole (400 mg by mouth, three times a day) and erythromycin succinate (400mg by mouth, twice a day).

He presented to one of us (PJF.) three days later with a swollen, bruised and painful left ankle and foot. A small cut, 1.5 cm in length, was held together with butterfly closures on his left ankle just above the lateral malleolus.

The area was infiltrated with 2% lignocaine with adrenaline (one in 250 000 dilution) and the butterfly closures were removed. A cut of about 1cm in depth was exposed which penetrated to the ligaments below. The area was examined by means of an operating microscope and pieces of foreign material were removed. The wound then was scrubbed with a toothbrush with hexachlorophene in 7007o alcohol. To keep the wound open and draining, a gauze wick that was soaked in saline was inserted. He was advised to return home and to continue antibiotic therapy, to rest and elevate the limb and to apply ice-packs to relieve discomfort and to reduce swelling in the area. Seven days later, the area was clean and granulating well; it had healed within two weeks.

However, when the wound again became hot and acutely inflamed six weeks later, a 3-cm area around it was excised and the wound was left open to granulate. The excised tissue contained many small fragments of confirmed stingray integumentary sheath. Over the next two months, the wound healed very slowly by natural intention and caused the patient significant loss of time from work.

Case 3
On October 25, 1988, a 26-year-old man was board-riding in 1 m of choppy surf off Harbour Beach, Mackay. Jumping off his board into shallow water, he felt a sharp stab on the bottom of his foot and discovered a 75-mm stingray barb embedded in the fourth toe of his right foot (Figure 2), but the wound was not particularly painful.

He presented to one of us (PJF) and the area was infiltrated with 207o lignocaine. The barb and a small area of tissue around it was excised and the wound was cleaned thoroughly with a toothbrush with hexachlorophene in 70% alcohol. As the barb had not penetrated the wound sufficiently, the integumentary sheath had not ruptured and so little, if any, surrounding tissue was envenomated. As a preventive measure, a small area around the tract was excised before the area was sutured to facilitate quicker healing.

The patient commenced to receive combined trimethoprin (80 mg) and sulphamethoxazole (400 mg), by mouth twice a day; a prophylactic injection of adult diphtheria and tetanus toxoid was administered. The foot was rested and elevated for one day after which the patient returned to work. No infection developed and the sutures were removed uneventfully a week later. No problem has developed subsequently.

Case 4
About midday on March 29, 1988, in Mouriylan Harbour, north Queensland, six persons were travelling in a 4.3-m aluminium boat at about 18 knots “on the plane”, over about a metre of water. It was an overcast, warm humid day with light winds; the tide had just turned and was ebbing; the water was sloppy- but there were no formed waves.

A large ray, which cannot be identified accurately, leapt out of the water in front of the fast-moving boat and glanced off all three passengers on the port side of the dinghy before falling back into the sea. The breadth of the ray's wings was described as "about two-thirds of an adult arm span" (about 1-m across). The three persons on the starboard side of the boat were untouched. The 12-year-old boy in the front of the boat and his father, who was seated at the rear and was steering the boat, were hit by the ray's wings but suffered no injury or visible markings. The other 12-year-old boy, I the centre on the port side of the boat, was hit by the ray and immediately complained of chest pain and that he "couldn't breathe properly". He had received a double strike". One barb had punctured and had broken off in the outer aspect of his left knee, but he also had received a puncture the size of and like a .22 bullet hole, right through his left nipple was not obvious immediately as he was wearing a shirt which slowly become blood-stained.

The boat was turned back to shore immediately. During the 10 minute trip back to the boat ramp the boy continued to complain of chest pain difficulty with breathing, although he did not appear to be breathless but was pale. During the 20-minute drive to seek medical help, the victim on his father's lap in the front of the car. As well as remaining pa complaining of chest pain and difficulty with breathing, the boy started sweating and appeared to become drowsy.

On his arrival at a general practitioner's surgery the patient was although in considerable pain from his wounds. On auscultation, his sounds were normal and his lung fields were clear. A 2cm curved laceration just under the left nipple was noted which still was bleeding slowly lacerations were present in the lateral aspect of the left knee, each 1-1.5 cm in length; one clearly represented the entry wound and the represented the exit wound. The latter still had an embedded 8cm barb.

Hot-packs were applied to both the chest and knee wounds which settled the pain before 1 % lignocaine could be injected into the area; the stinging barb was removed by simple traction before the patient was transfer the nearby local hospital. On arrival, his condition was stable: pulse 64 beats per minute; blood pressure, 110/75 mmHg; respiratory rate breaths per minute; and temperature, 36.CC. A plain erect chest x-ray was interpreted as normal (Figure 3) with no suggestion of a penetrating wound.

The track between the wounds in the knee was obvious and was scrubbed and irrigated with chlorhexidine gluconate in 70% alcohol. The chest w was less obvious with a degree of contusion of the underlying pectoral muscle. It was explored with a probe as carefully as possible; the tract appear extend laterally along the outer surface of the fifth rib and this whole area was cleaned carefully with chlorhexidine gluconate in 70% alcohol.

In view of the normal chest x-ray film, the absence of cough or haemoptysis and the patient's stable clinical condition, a penetrating chest wound was considered unlikely. A small vessel that had been bleeding persist beneath the nipple was tied off and the wound was left open to granulate. The boy was admitted to hospital for observation, but as no abnormal signs or symptoms developed subsequently he was discharged home the next day, 21 hours after the envenomation. Follow-up, some 48 hours after envenomation, showed him to be tired but well, and not complaining of symptoms. There were no obvious abnormal physical signs.

His father described a continuous improvement in the boy's condition the next few days until suddenly, six days after envenomation, then collapsed "gasping for air". His mother attempted to revive him with expired air resuscitation during the drive to the ambulance station. In spite of cardiac pulmonary resuscitation in the ambulance on the way to hospital and medical personnel at the hospital, he could not be revived.

A post-mortem examination was performed approximately five hours after death, and six days after envenomation. The only external signs were a healing 2-cm laceration under the left nipple; and a healing 1cm laceration over the lateral aspect of the left knee. Healing puncture wounds were present both on the pleural surface under the nipple and surrounded by haematoma over the anterior and lower aspect of the upper lobe of the left lung. This latter puncture wound was visible over the left mid-pericardium and the pericardial cavity and contained approximately 1-cm thickness of clotted blood. In the left pleural cavity 70-100 mL of blood were present. This was fresh and had leaked out when the ventricle had perforated (Dr John Di Palma, personal communication). The puncture wound was visible with approximately 3mm of surrounding necrotic tissue, which extended through the upper aspect of his right ventricle into the cavity of the right ventricle. The cause of death was cardiac tamponade as a result of chemical myocardial necrosis from a penetrating stingray wound.

Tangalooma study

One of us (RAS) now has treated more than 100 cases of minor stingray envenomations at Tangalooma Resort, Moreton Island, Queensland. These usually involve small painful puncture wounds on the leg, which have occurred after an unsuspecting tourist has jumped from a boat into shallow water and has stood on a small stingray. The rays are about the size of a dinner plate, and may be present in their hundreds.

The treatment of these painful little wounds has been to anaesthetize the area with 1 % plain lignocaine and then to scrub them with povidone-iodine with a toothbrush and/or to irrigate them with povidone-iodine. The local anaesthetic agent is injected through the wound primarily because it affords immediate relief by this route. It also allows the injecting needle to act as a probe, seeking pieces of broken barb. Although there is a hypothetical risk of forcing toxin or infected material into the surrounding tissue, there has been no clinical evidence of such an occurrence.

In three cases, wounds showed both entry and exit puncture holes in the skin. These were irrigated with povidone-iodine by way of the plastic cannula of an intravenous infusion device.

Plain lignocaine was employed in case the inclusion of adrenaline might have aggravated local wound necrosis. In most cases of envenomation, the lacerations were small, although one laceration was 30 mm and another was 45 mm in length. The lacerations were not sutured but were allowed to heal by granulation. Tetanus immunization was administered if necessary. At the commencement of the study, tetanus toxoid was used but this was changed to combined adult diphtheria and tetanus toxoid when this became the recommended tetanus prophylaxis for adults in Australia.

As almost all such patients were visitors to the Island, follow-up of most of them was not possible over any period, although no further morbidity occurred in those patients who could be observed. In such minor wounds routine prophylactic antibiotic therapy was not used and those cases that; were reviewed indicated that it was not necessary; however, in larger wounds antibiotic therapy probably is indicated.

While treating these victims, it was observed that 1 % lignocaine infiltration appeared to produce a pain-relieving effect in the wound before the onset of local anaesthesia. In five such patients, an area of skin remote from the actual envenomation site was infiltrated with 1 % lignocaine at the same time as was the envenomated area. When the envenomated area became pain free, the remote area that was injected still remained sensitive to pin-prick, even when allowing for the time of injection. It is possible that either the tissues, which are damaged by the stingray venom, are more susceptible to the analgesic action of lignocaine, or that lignocaine has some direct ability to counter the toxin, which is injected from the barbs of the stingray, or possibly both. This matter will be investigated further.

DISCUSSION

The wound that results from stingray envenomation is caused by an arching-forward flick of the ray's tail (Figure 4), which is triggered by reflex action when the wings of the stingray are disturbed, as when trodden on or otherwise stimulated.' The jagged saw-edge of the barb then may cause a skin laceration, or the sharp pointed barb may puncture the skin; the integumentary sheath then can rupture, causing severe pain or even (rarely) systemic venom effects. In one large study, 5% of the barbs broke off to remain *in situ*.

In our study, every case (except one) of envenomation, whether lacerations or simple skin penetration were involved, was painful. It has been reported that in approximately two-thirds of documented stingray puncture wounds a protein venom is deposited which causes the severe pain and subsequent local tissue necrosis and that regional nerve block may be necessary to ease the pain. Large peripheral envenomations also have been recorded as causing disturbances of the central nervous system's and heart's actions.

A survey of the medical literature on stingray envenomation suggests that the majority of injuries is lacerations of the lower limbs this was confirmed by our study. Venom-mediated tissue necrosis or subsequent infection in an area such as the lower limb always delays healing, and seems to be associated with greater morbidity (as in Cases 1and 2).

The currently recommended first-aid treatment of stingray envenomation first was suggested by Starks in 1918," and includes the immersion of the affected part in water as hot as is bearable (not boiling!) to denature the heat-labile venom and to provide rapid pain relief. If hot water is unavailable, then the hot sea-water from the cooling system of a boat's motor may be a suitable alternative. Care must be taken that accidental burns do not occur (the painful envenomated area and the distressed victim often are less sensitive to beat or cold'). Therefore, it is recommended that the water temperature first be tested by the person supervising first aid.

Cryotherapy has been an accepted therapy for pain relief in sporting injuries for many years,` and recently cold-packs also have been found to be effective as local anaesthesia in many jellyfish stings." Based on this recent research, topical ice- or cold-packs are the treatment for non-cuboidal jellyfish stings that currently is recommended by the Queensland Surf Life-Saving Association and the Queensland Ambulance Services Board." Ice has been recommended as a treatment for stingray wounds and perhaps may be considered when heat is not available or when heat treatment fails to provide sufficient relief. However, in trials by Russel *et al*,3 ice not only failed to provide any relief from stingray injuries, but actually seemed to make the pain worse. Our recommended treatment for stingray envenomation is shown in the box.

Extensive questioning of local fishermen failed to reveal any previous knowledge or experience of a stingray actually colliding in midair with people in a moving boat, although many had seen stingrays leaping out of the water. More than 20 species of stingray have been described, several of which have one or more barbs on the tail.' An unconfirmed report suggested that the stingray which caused the fatal envenomation may have been an eagle ray which has up to six barbed spines." Eagle rays also are reported to give birth to their young as the mother repeatedly leaps out of the water.' However, the species that was responsible for this fatal envenomation remains unknown.

Presumably, the stingray had leapt out of the water in fright at the rapidly approaching boat. It is possible that the contact between the wings of the ray and the boy who was sitting at the front of the boat caused the reflex---whip-of the tail, which then resulted in the barb striking the second boy who was sitting further back. This strike produced penetration of the chest wall, the left lung,' the pericardium and the right ventricle; apparently, the barb then cleanly withdrew in the next instant as the ray flew past. It appears that this wound then immediately, but temporarily, sealed itself, causing only short-lived acute symptoms of envenomation, but no definite clinical clues, at that time, to the real extent of penetration.

As illustrated, the chest x-ray films that were taken at the time of this initial penetration were, not unreasonably, considered to be normal (Figure 3). Subsequent close scrutiny of these x-ray films under ideal conditions by two specialist radiologists revealed a mark, presumably a tiny pleural effusion (probably a small amount of blood), which was visible at the left costophrenic angle on the inspiratory film (Figure 5); even more obscurely, a suggestion of pericardial distension was present at the left basal margin of the heart shadow. We believe that such subtle signs could not be expected to be detected under normal conditions, but even if they had been, this would not have modified the clinical outcome.

Clearly, over the next six days, the deposited venom from the barb's integumentary sheath produced an insidious and progressive localized myocardial muscle necrosis, which led to acute cardiac perforation, tamponade and sudden death. The 70-100 mL of blood in the pleural cavity at autopsy was fresh and, presumably, had leaked out at the time of pericardial rupture and subsequent external cardiac compression - which would account for it not being visible the original chest x-ray film (Figure 3).

It has been suggested previously, and we concur, that less morbidity occurs when the fresh barb wound is cleaned carefully or where appropriate, even excised locally after some form of local anaesthesia. Indeed, it should be stressed that all stingray wounds must be explored fully, and be examined radiologically for the presence of retained barb fragments, even if they appear to be clean. In hindsight, such an approach in our fatal case would have suggested patient transfer and such heroic measures as thoracotomy and localized myocardial muscle excision which, in view of the state of the patient's health at that time, scarcely would have been considered even if the full extent of the penetration had been detected.

However, from this experience we now are inclined to a (mindful of the now well-documented necrosing action o venom), after appropriate consultation, that patients with penetrating stingray barb injuries to the chest wall at least should be transferred to a medical centre where thoracotomy is available. In these clinical circumstances, what is required is an investigative procedure (preferably a non-invasive one) which provides early recognition o progressive tissue devitalisation in a vital organ such as the before an acute crisis (for example, perforation and haemorrhage actually occurs.

Cardiac enzyme studies, for example, would be expected to provide too little information too late. Likewise, echocardiography and/or radiographic imaging could not be expected to detect localized tissue early enough. Radiologists have suggested technetium pyrophosphate or thallium isotope scanning, where heart muscle is involved." These monitor the perfusion of the myocardium such an approach could be expected to reveal tissue damage the first 24 hours. This may permit planned surgical intervention in clear cases of the presence of dying tissue, before perforation occurs spontaneously.

Significant morbidity, as well as deaths, has resulted from penetration of body cavities by stingray barbs.','-" Death Australia' and New Zealand' also have resulted from a penetrating chest wound; however, these patients died within a few minutes as a result of, we suppose, either the direct effects of the stab or the systemic toxic action of the venom. Another previously unreported case of a chest wound that was caused by a penetrating stingray barb was encountered by one of us (JAW.) in 1972 adult patient sustained his injury when he pulled a netted stingray on board his boat out at sea off Mackay, north Queensland was transferred to hospital for a thoracotomy about three day with a pyopneumothorax and systemic toxicity. After surgical drainage of his empyema, and appropriate supportive he made an uneventful recovery.

Prevention is always easier than cure and fishermen should be aware that stingrays must be treated with respect. Professional fishermen should take care with netted rays in enclosed spaces on board their fishing boats; amateur fishermen would be well-advised quickly to

sever the line should they catch a stingray. No attempt should be made to pull the ray on board.

Care should be taken while walking or moving in shallow, water which stingrays are known to frequent. They commonly lie flat on the bottom, completely still and well camouflaged by sand and rubble, which they have allowed to settle over themselves. In shallow water, waders should "shuffle" slowly forward, should wear heavy clothing over their legs and strong boots, and carefully prod the area ahead with a stick.

Recommended treatment of stingray injury

First aid -

- If medical aid is not available immediately, place the affected area in water as hot as can be tolerated without burning (test first!). Seek medical aid. If heat is unavailable or fails to provide relief, then ice or ice-packs are applied to the area for up to 30 minutes and, if they help, are reapplied

Medical management -

- If necessary, inject local anaesthetic agent (1% plain lignocaine) directly into the wound and around the site of envenomation to ease the pain.
- Perform x-ray examination of the wound area for traces of foreign material
- Explore the wound carefully, following the full length of any tract, which may be left by the penetrating barb. Remove all traces of broken barb or integumentary sheath and clean the wound with hexachlorophene in 70% alcohol; if available, use an operating microscope.
- Leave the area open to granulate
- Administer tetanus vaccine or adult diphtheria and tetanus toxoid, if indicated.
- Antibiotic therapy should be considered if the injury is more than six hours old and/or Is extensive (Figure 1)
- Patients with wounds that are considered to penetrate to the abdomen or chest should be referred immediately to experienced medical centres for further assessment
- Follow-up of all wounds is necessary until they are healed fully

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