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Bashkiria train–gas pipeline disaster: a history of the joint USSR/USA collaboration

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In June 1989, a methane/propane pipeline explosion destroyed two passenger trains in the Bashkirian Republic of the Soviet Union. Over 400 passengers died immediately and 806 were injured. Most of those injured suffered thermal injuries. One hundred and fifty patients were treated at Hospital 21 in Ufa, Bashkiria, by a combined Soviet–US team. Twenty-six patients underwent excision and grafting of their burn wounds. Microbiological studies indicated significant resistance to locally available antibiotics. Antibiotics provided by the US team proved useful in treating the resistant organisms. This disaster and the international response to it exemplify the need for a coordinated response to major burn disasters and the positive results of international cooperation.

Introduction

Advances in science and technology have increased the risk of accident which result in thermal injury to persons located nearby. As more powerful sources of energy are harnessed the number of casualties in such an accident increase. This has led to a number of mass casualty incidents (Layton, 1982; Allister and Hamilton, 1983). Such disasters normally exceed the resources of local health care providers and facilities. When the accident occurs in a remote location, the difficulties in caring for the victims become even greater. Herein we describe what is, to our knowledge, the largest railway disaster in the history of man with respect to the number of burn casualties. This disaster was also unique in that it represented the first joint effort by the Soviet health care system and the US Army since the Second World War. The combined efforts of these two groups, plus civilian burn teams from a number of countries, emphasize several points. First, when a burn disaster involves many hundreds of patients, it will usually be necessary to have burn teams from many countries participate in order to achieve optimum care for the victims. Secondly, such collaboration is possible, especially when such teams have made plans in advance of such accidents with regards to transportation of their teams and equipment to a site many thousands of kilometers from their home base. Finally, such teams working together can exchange new ideas and techniques with colleagues from other parts of the world who are not familiar with such techniques. We also describe the history of the combined efforts of the Soviet and US Army medical teams as they worked together at the largest hospital in the city of Ufa. Neither this hospital nor the Soviet doctors working at the hospital had had significant burn care experience prior to the disaster.

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Report on the disaster

At 01.15 h on 4 June 1989, the largest railway accident in history took place in the Soviet Republic of Bashkiria. The accident was due to an explosion of leaking natural gas from a pipeline adjacent to two railway lines. Two passenger trains carrying approximately 1284 passengers were passing in opposite directions immediately adjacent to the site of the gas leak at the time of the explosion. *Figure 1* is a photograph of the accident site. Over 400 individuals perished immediately while others received injuries of various degrees. Burns constituted a large majority of these injuries.

First aid was rendered to the victims at the site of the accident by local inhabitants and medical staff of hospitals located in nearby settlements. Within 12 h, 25 teams of emergency first aid personnel arrived from the city of Ufa (population 1 200 000) and the Civil Defense Medical Brigades.

During the initial stage following the accident, the victims were evacuated to nearby settlements where first aid was rendered, aseptic bandages were placed, and fluid resuscitation was started. During the second stage, the victims were evacuated by medical vehicles and helicopters to Ufa (100 km from the accident site) and Tchelyabinsk (250 km from the accident site). The evacuation of all victims was completed by 1800 h on 4 June. The total evacuation took 16 h 45 min. Altogether, 806 persons were admitted to the surgery departments at the larger hospitals as well as in special burn centres.

At the time the accident occurred, Ufa City Clinical Hospital 21 had 23 surgeons on duty. The information about the accident was received by the senior duty surgeon at 02.38 h. Hospital authorities and engineers were notified through the civil defense system. Simultaneously, formation of specialized medical teams for rendering aid to the victims at the accident site was initiated. Five crews, including resusci-

Figure 1. Accident site in Bashkiria after pipeline leak and explosion.

tation and anaesthesiology (resuscitation of trauma victims is frequently performed by anaesthesiologists in the USSR medical system), neurology, toxic resuscitation, and traumatology, capable of self-sustained work, were formed and sent to the accident site.

At Hospital 21, 200 beds, including 56 beds normally utilized for alcohol detoxification, had been made ready to receive the patients by 08.00 h on 4 June. Two sorting and seven dressing stations were established in the Casualty-Diagnostic Department. A number of off-duty crews were called in and arrived immediately after alert notification. Mobile physician crews were organized, which included two triage crews, each consisting of one surgeon, one registrar and one treatment nurse, seven surgery-dressing crews, each consisting of one surgeon and one dressing nurse, and three resuscitation crews, each consisting of one resuscitation doctor (anaesthesiologist/intensive care specialist) and one hospital nurse. At each surgery ward proposed for the hospital treatment of the victims, one surgeon and one therapist were stationed. A department of blood transfusion was established and drugs, additional dressing materials, and sets of instruments were made ready.

On the first day, 116 victims from the accident site were admitted to Hospital 21 in Ufa. During the following several days, 38 additional patients were transferred to Hospital 21 from other medical institutions. There were 90 male (58.4 per cent) and 64 female (41.6 per cent) patients. There were eight children (5.2 per cent) younger than 14 years of age. Twenty-seven patients (17.5 per cent) were 14–20 years of age, 49 (31.8 per cent) were 20–30 years of age, 29 (18.8 per cent) were 30–40 years of age, 16 (10.4 per cent) were 40–50 years of age, 15 (9.7 per cent) were 50–60 years of age, and 9 (5.9 per cent) were >60 years of age.

One hundred and forty-nine patients (96.8 per cent) were admitted with flame burns and five with injuries other than burns. At the time of admission, 13 patients (8.4 per cent) were in an extremely critical condition, 46 (29.9 per cent) were in a serious condition, and 20 (13.0 per cent) were in good condition. Forty-eight patients had <20 per cent total body surface area (TBSA) burns, 25 had 20–30 per cent TBSA burns, 32 had 30–40 per cent TBSA burns, 15 had 40–50 per cent TBSA burns, seven had 50–60 per cent TBSA burns, and seven had >70 per cent TBSA burns. Thirty-three patients (22.1 per cent) had partial skin thickness burns, 107 (71.8 per cent) had both partial and full skin thickness burns, and nine (6.1 per cent) had burns extending into muscle and bone.

Burns with associated injuries such as fractures, cranial-cerebral trauma, and tissue injury with foreign bodies were noted in 25 patients (16.2 per cent). Fifty-six patients (36.4 per cent) had inhalation injury as evidenced by facial burns with singed nares and carbonaceus sputum. Poisoning with carbon monoxide was noted in five patients. The limited number of victims with central nervous system injuries was possibly the result of the fact that such victims were unable to flee the burning vehicles and therefore perished.

There was a preponderance of facial and extremity burns. Ninety-four patients (63.1 per cent) had burns of the upper extremity, 58 (38.9 per cent) had burns of the lower extremity, 70 (45.5 per cent) had head burns, 25 (16.8 per cent) had

burns of the back, 11 (7.4 per cent) had chest burns and eight (5.4 per cent) had abdominal burns. The deepest burns were primarily on the upper and lower extremities and were frequently associated with muscle and bone pathology due to fractures resulting from the explosion and/or from prolonged contact with burning metal. It is our opinion that these features were due to the two-stage character of thermal injuries, i.e. initial burns caused by the flames from the explosion which produced more extensive and less deep burns (in such cases, even ordinary clothes were noted to provide some degree of protection) and subsequent burns caused by the railway car sheathing burning which gave less extensive but deeper burns of the extremities.

The burn patients were gathered in two temporarily established burn departments which each had 40 beds as well as two intensive care units. In these units, isolation techniques were established, including sterile air filtering, strict mask utilization, and thrice daily antiseptic cleansing of all furniture and premises. In combination with selective antibiotic therapy, these measures helped to decrease the incidence of infectious complications.

Frequent bacteriological monitoring of wound discharges as well as blood, urine and sputum was performed. Seven hundred and ten bacteriological samples were taken and 2543 bacteriological tests were performed. *Staph. aureus* was detected in 93 cultures and *Ps. aeruginosa* was detected in 149 cultures. Blood samples were obtained in 116 patients and were positive for bacteria in 14 patients (12.1 per cent). The incidence of positive cultures peaked from days 11 to 14 postburn. From conventionally pathogenic flora, Gram-negative micro-organisms (enterobacter and klebsiella) predominated. These organisms were frequently resistant to most of the antibiotics used in the USSR. However, they were sensitive to the antibiotics (amikacin, ceftazidime, ticarcillin and vancomycin) supplied by the US Army Institute of Surgical Research team of military physicians from San Antonio, Texas, USA. These antibiotics were therefore utilized for both perioperative prophylaxis and treatment of existing infections according to standard western guidelines.

Burn wounds were treated topically with water-soluble linaments consisting of levamisole, Dioxicol and Levacin which had been developed in the USSR and found to possess a therapeutic effect.

Fifty-one sessions of blood ultraviolet treatment in 12 patients, 10 splenosorptions in five patients (Chizh et al., 1989), two haemosorptions in two patients, 12 plasmapheresis in four patients, and eight plasma screenings in three patients were conducted in an attempt to remove any bacterial or burn toxins present in the blood and to stimulate the patient's immune system. *Figure 2* is a photograph of a splenosorption during which catheters are placed into the femoral and subclavian veins. Blood is removed from the femoral vein by roller pump, and perfused into the artery of a pig's spleen. The effluent from the splenic vein is then returned to the patient's subclavian vein. This perfusion is continued for approximately 1 h. It is hoped that the procedure will improve immune function in the patient. All patients survived 'shock' with these procedures. Following early treatments, 48 patients (31.0 per cent) were transported for subsequent care at other burn centres in the USSR.

On 8 June 1989, the United States Army Institute of Surgical Research in San Antonio, Texas, USA, was informed that an offer of assistance from the Institute by President George Bush had been accepted by the Soviet Government. The Institute was directed to proceed immediately to Ufa with personnel and supplies. Following the arrival of the team from the USA, aggressive surgical interventions of the burn wounds in patients with deep bu. were started according to the technique of Janzekovic (1970). On postburn day 6, excision and grafting of the patients began. In total, 26 patients (18.8 per cent) were operated upon jointly by US and Soviet surgeons. Excision of the burn wound was performed using the electrical Padgett dermatome and Gulian hand-held knife with subsequent grafting utilizing split-thickness skin grafts. Ninety-eight per cent of all grafted wounds healed following initial surgery. The average length of stay for patients with full skin thickness burns was 29.5 days. The average postoperative stay was 18.2 days. There was one postoperative death (3.6 per cent). Donor sites were treated with fine-mesh gauze and exposure. This allowed an average healing period for the donor sites of 12 days. Partial suppuration of the donor areas was noted in two patients (7.2 per cent). These healed without surgical intervention.

Figure 2. Patient undergoing veno-venous xenospleen perfusion.

The treatment of the burn victim combining traditional conservative methods of burn treatment by methods applied in the USSR and aggressive surgical excision and grafting of deep burns used by the US surgeons achieved good results. Seventy-two patients recovered and were discharged (48.7 per cent), 25 patients died (16.0 per cent) and 54 (35.3 per cent) patients were transferred for treatment to other burn centres within the USSR or other hospitals within the city of Ufa.

Mass casualty care situations have taxed the abilities of local medical establishments to care for the injured. These difficulties are the result of the suddenness of the accident, delayed notification of appropriate medical facilities, difficulties in initial identification of the number of victims, and coordination of available medical personnel and facilities. These difficulties can be decreased if contingency plans, which establish appropriate protocols for handling such situations, are made in advance of any accident.

The recent disasters in Armenia and Chernobyl have emphasized to Soviet Health Ministry officials the importance of having such plans. This led to the rapid triage and transport of victims from the accident site to the medical centres in surrounding towns.

The Soviet experience during the accident demonstrates

that such an organization of the public health service permitted the rendering of aid to the majority of the victims in a rapid and appropriate time-frame. At the accident site, each team headed by a qualified physician gave aid to 25–30 victims. When admitting patients and rendering qualified and specialized medical aid at a hospital (as a rule, at a temporarily organized burn centre), the participation of mixed physician teams (a surgeon, a burn specialist, resuscitation therapist) is advisable. The average number of patients per team was 12–15.

Catheterization of major vessels should be conducted at the accident site with subsequent initiation of fluid resuscitation therapy at the site and during the evacuation. The optimum method of transportation over distances exceeding 50 km is by air (helicopter). It is advisable to evacuate accident victims to the nearest well-equipped hospitals where the organization of temporary burn centres in the shortest time is possible.

The specific problems of rendering aid in such exteme situations testifies to the necessity of having an organization for, or separate departments of, 'catastrophe medicine'.

The joint work of Soviet and US physicians during this unprecedented accident once more demonstrated the efficacy of international cooperation. In planning for the care of victims of future disasters, such international cooperation should be included.

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