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Special Article

Historical Development in Trauma and Burn Management in Thailand During the Years 1970 to 2010

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Background

Before the year 1970, the morbidity and mortality rates in the care of trauma and burn patients seemed likely to be high, even after the discovery of better fluid resuscitation methods and better topical and systemic antibiotics. The leading cause of morbidity and mortality was delayed diagnosis and treatment of severely injured patients. Following the experiences of caring for severely injured patients during the Vietnam War, it was realized that early diagnosis and early appropriate management was of utmost importance. After 1970, physicians, especially surgeons, in different regions of the United States of America worked with thoughtful diligence to obtain advanced knowledge and skills through wide-ranging research programs, for the benefit of both trauma and burn patients. Many new surgical procedures were developed and applied to this group of patients. Treatment was begun early and resulted in better outcomes. Most Thai surgeons of that period undertook their postgraduate training in the United Kingdom, or some other European countries such as Germany, and were thus more conservative in their treatment of patients. At the same time a few Thai surgeons were completing their training in the United States, who by contrast seemed to be more radical and aggressive towards treatment[1-3].

During the decade between 1960 and 1970, the Vietnam conflict saw the recruitment of many American physicians to care for the wounded overseas. Doctors from Thailand, myself included, and those from other Asian countries were sent for further medical training in the United States to help support American

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physicians both in and outside the United States[1,3,6].

In 1965, two years after I graduated in medicine from the Faculty of Medicine, Siriraj Hospital, and after one year of internship as well as one year of surgical residency, I left for the United States and entered the matching program. In 1966, I participated in a one-year surgical internship at Albany Medical Center Hospital (AMCH) in Albany, New York. After completion I was accepted as a first year, and subsequently second and third year, surgical resident. In the fourth year I was chief resident, but without an additional year of research in the laboratory. With great pride I was the first foreign chief resident at this hospital under the supervision of my boss, Professor Charles Eckert, who was a distinguished service award recipient of the American College of Surgeons.

I completed the residency training in surgery in 1970, and then enrolled as a Fellow in vascular surgery, and did some research for another year at the same institute (AMCH), in 1971 and again from 1971-1972. I was recommended by Professor Harvey Bernard at the Department of Surgery, Albany Medical Center to extend my training in burns for one more year under his friend, Professor William Monafo, one of the top burn surgeons, who was working at St. John's Mercy Medical and Burn Center in St. Louis, Missouri. At that time, Professor Monafo was a pioneer in using Hypertonic Saline Solution (HSS) to resuscitate burn shock, instead of Ringer's Lactate Solution, during the first 24 hours of burn injury.

During my one-year training with Professor Monafo, I learned many things, especially the care and management of burn patients. In 1972 I became a Diplomate of the American Board of Surgery with a Certificate of Fellowship in Vascular Surgery and Research, and a Certificate of Fellowship in Burns. In mid-July 1972, after 7 years of work in the United States my wife and I returned to Thailand, our lovely country[2,7].

I started working in the Department of Surgery, Faculty of Medicine, Siriraj Hospital under the recommendation of Professor Williams Monafo, who wrote to Professor Lim Kunvisan, the Department Head. I was also invited to work in the Division of Traumatology, which was at the time a new division of the Department of Surgery, established in 1972. This was the first trauma unit in Thailand. I started seeing trauma patients in August 1972, and was appointed an instructor in Surgery on 2 January 1973.

I was one of five staff surgeons in the Division of Traumatology. I took great pride in caring for trauma and burn patients as there were very few Thai surgeons within the extensive field of surgery who could take care of trauma and burn patients at the same time. I believe the Holy Soul wanted me to work there and that the fates of trauma and burn patients, and myself, were inextricably entwined. To me, this means that everyone must work hard for the future.

With the experience and knowledge which I obtained from the United States, I was certain that I would do everything necessary for my patients, with the utmost good intention and responsibility, by working as hard as my intelligence would permit, and to try to follow whatever Somdej Praraj Bhiddha, or Prince Mahidol, Father of the Present King of Thailand, had taught us. He was the first modern and progressive doctor in Thailand when he graduated in Medicine from Harvard Medical School. He taught us what doctors should ethically and professionally do for, and behave toward, our patients[2,4].

According to Mahidol University Regulations, every staff physician who officially works in a medical school must do the following:

1. Teach and train medical students and residents attached to his or her Department;
2. Service patients;
3. Basic and/or clinical research;
4. Administrative work.

My first duty was servicing trauma and burn patients who were admitted, or referred from other hospitals, to our Department.

As additional background information, I would like to describe my working with trauma and burn patients in those days. As I mentioned earlier, my past training and experiences allowed me to care for trauma patients with injuries from the head down to the heel of the foot, especially at times when no other trauma specialists including neurological and orthopedic surgeons were available in the hospital. I was able to provide initial treatment to patients with head injury who required an emergency Burr hole, or patients with associated long bone fractures and joint injury, or with severe pelvic fractures requiring stabilization. For patients who had long bone fractures associated with vascular injuries I would discuss the problem with the orthopedic surgeon, to decide who should do the surgery first, or whether to do surgery together in the

same setting.

At that time, patients with severe fractures of pelvis and shock at the scene of injury would be provided with G-suites covering both lower limbs and around the pelvic region applied by the ambulance service personnel, but this is no longer done as some patients might develop severe compartment syndrome of the lower extremities[18,19].

For injuries to the head and neck region from both penetrating and blunt trauma, except neurological and orthopedic injuries, I usually managed alone, such as in a case of total scalp avulsion where I was able to put back the scalp as a full thickness skin graft. I was also able to handle cases of carotid artery injuries[12].

For trauma to the chest region including lungs, cardiac injuries and injuries of the esophagus, I was able to do most of the operations, except for traumatic aneurysms of the aortic arch which might require the help of cardiothoracic surgeons.

Similarly, most abdominal injuries from both blunt and penetrating trauma to various organs in the abdominal cavity, was operated on by me; but the outcome would depend on the severity of the injured organ and associated injuries both inside and outside the abdomen.

In the case of extremity injuries from both blunt and penetrating trauma, I would take care of the soft tissues such as those associated vascular injury, infection, avulsion of skin and severe necrotizing fasciitis, and the orthopedic surgeons would take over the joints and long bones. I also operated on hand injuries, except when microsurgery was required[1,5,6,15,16].

Clinical Research and Innovation

I preferred to treat trauma patients as well as do clinical research at the same time if possible. This was because trauma patients often present with very complicated problems, as in the case history of the following patient who developed severe septic abdomen after blunt trauma of abdomen. This particular patient, ten days after the initial emergency operation for blunt abdominal trauma resulting in the complete transection of the proximal part of jejunum with severe contusion of pancreas, in which the first surgeon who did the surgery had repaired the jejunum and placed multiple Penrose drains around pancreatic region before referring the patient to us, developed very high fever with foul smelling discharge from the drainage wounds. The diagnosis of severe septic abdomen with multiple organ failure (more than four systems) was made, and one day after referral and after adequate resuscitation, the abdomen was reopened, revealing severe acute hemorrhagic necrotizing pancreatitis associated with gangrenous colon due to severe damage to its mesentery, which required near total colectomy with ileostomy and distal sigmoid colostomy and leaving the abdominal wound open with intra-abdominal packing to control the diffuse bleeding and to remove tissue debris due to inflammation from the pancreatitis. We subsequently performed several re-explorations of the abdominal cavity, but kept the wound open to ensure that there was no collection. After the granulation tissue grew to cover the exposed bowel wall, split thickness skin graft was performed to cover the wound.

In general, a patient who develops severe abdominal sepsis with multiple organ failure of 3 systems or more would have a mortality rate of over 70%. This patient was given total parenteral nutrition for six months. In addition, the patient developed a large gastric fistula following the resection of a massively bleeding gastric ulcer. The patient ultimately survived, and was discharged while able to eat fairly well. The patient returned for a subsequent closure of the ileostomy and sigmoid colostomy, as an end to end anastomosis of the distal ileum to the sigmoid colon, and the ventral hernia was closed by approximating the skin and fascial edges of the abdominal wound with simple interrupted sutures. He did very well after surgery and fully enjoyed life at home. He never forgot how we cared for him, which gave him back his life. He was appreciative and extremely grateful.

The number of admitted trauma patients under my care was probably larger than that of any other staff surgeon in the Division of Traumatology. Other staff surgeons would refer many severely traumatized patients to me, and I was the only surgeon in the Division who looked after burn patients for several years until new staff members were recruited to join me (2006). Plastic surgeons would come to see some of the burn patients in the burn unit.

A severely burned patient was considered to be most seriously ill, and I agree with this assessment because burn patients were at high risk of developing

infection and sepsis at any time, and after a prolonged shock, he or she could expire early and suddenly. Most burn patients who survived early on required a prolonged hospital stay. The appropriate and adequate fluid resuscitation played the most important role in helping patients pass through the shock phase. During resuscitation we must determine the extent and depth of the burn wound, as patients with deep dermal burn or full thickness skin burn of the trunk and extremities required decompression of those areas by escharotomy or fasciotomy so that compartment syndromes in the affected parts of the body could be prevented. The appropriate timing of early excision of the eschar must also be determined. Early nutritional support also played an important role, and if possible early enteral feeding was preferred. This would improve the patient's immunity, promote wound healing and prevent infection[5,6,7,11,18,19,20,24,25,36,38].

When I first started to see burn patient after the new trauma building was built, there was no area for a separate burn unit, and before my return from the States most burn patients were under the care of plastic surgeons. After my return, officially appointed Instructor of Surgery, and as I was certified by the American Burn Association, my intention was to upgrade and modernize the way burn patients were cared for to the American level. Because many essential components such as dressings and equipment for burn management were not available in Thailand at that time I had to be innovative and created from scratch much of what was needed. For this, clinical studies were required. However, we had to be very careful of unexpected events even in those days since there was no ethics committee to determine the risk or benefits of these studies.

Although I had some trouble finding a place for admitting burn patients, I finally found an isolated room near the trauma ward which could accommodate two to three burn patients. I received help from nurses in the trauma ward who volunteered to work with burn patients and helped with changing the burn dressings every day. I myself bought a used water tank so that we could bathe and change dressings for burn patients at least once a day, which I did for at least five years before a new burn unit was created on the top floor of the trauma building. This was the first burn unit in Thailand, opened in 1978[31].

Because burn patients needed a diet high in protein and energy and the hospital had only a few nutritionists available, I decided to return to America to gain some insight as to how to achieve this. After coming back to my work I got an idea of preparing a blenderized diet composed of high quality proteins from eggs. We used eight eggs (just a little boiled) in one liter of a blenderized formula. If an adult burn patient receive two liters of this diet per day, even a large burn patient would get enough protein. We gave this diet preparation to our burn and severe trauma patients, and they seemed to do better in terms of shorter wound healing time and shorter hospital stay. We used this blenderized diet at the time when commercial high protein formulas were not available. Total Parenteral Nutrition (TPN) might be given in cases of impaired bowel function.

After 1990 we were able to prepare a new diet formula called the Immune Enhancing Diet (IED) which contained immunologically-active amino acids and other nutrients such as glutamine, arginine and omega-3 fatty acids. We achieved some success with this preparation with the help from a Japanese Pharmaceutical (Thailand) Company who also helped us develop a diet formula called "Neomune". This diet was able to promote immunity by adding certain amino acids such as ornithine and arginine, helping raise the ratios of CD4 and CD8 cells. Wound healing rates in burn patients were becoming faster, with early skin grafting and with less wound infection. We also started enteral feeding fairly early. This would improve patients' immunity as well[22,33,34,35,36,37,39,40,42,45].

There were some patients with deep dermal burns of less than 20% TBSA (Total Body Surface Area) in whom we had performed early excision of the eschar within the first five days of burn injury, with immediate skin grafting and very impressive results. We had done this procedure on at least 10 of 38 burn patients in our early experience.

Close to the end of the last two decades, some American burn institutes achieved some success in preparing and using skin substitutes, trademarked as Integra, on their burn patients. We missed out on this because the cost was prohibitive. Our burn unit started to use skin substitutes after cheaper products from Japan, such as Terudermis and Pelnac, became available[1,6].

Topical burn wound dressing was previously used in combination with silver ion, such as the 1% silver

sulfadiazine, and later that silver was replaced by smaller silver ions called nanocrystalline silver. This silver fragmented into very small silver ions which were able to penetrate through bacterial wall membrane into the nucleus, and blocked cellular respiratory enzymes, thus working clinically as an antibacterial and anti-inflammatory drug. In burn wounds the use of nanocrystalline silver resulted in better wound healing. The nanocrystalline silver was used by Smith and Nephew Company to create a new wound dressing cream called "Acticoat", and I had the opportunity to conduct clinical studies examining its effects on burn wounds during the years 2000-2003. I especially liked its anti- inflammatory properties[14,43].

The other changes in burn care, in the era of progressive electronics and high technology, was related to devices used for burn wound debridement. Previously we used hand dermatomes, either a Gullion or Watson skin graft knife, for removal of the burn eschar and for skin graft harvesting. Recently we acquired a new device called the Versajet Hydrosurgery System, operating a high pressure water coming through the tip of a suction-tube like equipment. It enabled the removal of the burn eschar with less trauma and less bleeding, shortening the time of operation[24,25,26,27].

I believe that the principles of burn care which I learned during the period of my training in the United States are not too different from those of today. Any noticeable changes in management usually concern electronic and technological advances, such as in surgical devices, and topical antibacterial agents and various kinds of wound dressings[11,40,41,42].

One principle in the care of critically ill patients concerns nutritional support to maintain adequate immunity. Critically ill patients require higher intake of energy and protein. During the 2 decades between 1970 and 1990, Thailand was considered as somewhere between a poor and a developing nation, and we faced shortages of essential drugs, technology and products needed by our seriously ill patients. So I would like to describe what was done during the two decades for our patient's benefit, and the innovations which went through the clinical research study phase before they became widely used.

In addition to Chomchark's modified fluid formula for burn shock resuscitation, a type of Hypertonic Saline Solution (see below), we introduced fresh human amnion as a biological dressing, instead of using porcine or pig's skin as in the United States, for burn wounds. We found that fresh human amnion was a most excellent biologic dressing for burn wounds, particularly for superficial second degree burns, as well as being cost-effective. I was the first person who introduced the amnion for medical use in Thailand in 1973.

We also introduced new topical burn wound dressings, one of these was 1% silver-zinc sulfadiazine cream, modified from the 1% silver sulfadiazine which originated with Professor Charles Fox, a biochemist at Columbia University, New York. I asked his permission to make this preparation when he stopped by on his way to Sidney, Australia to visit our burn unit several years ago. As you know zinc is one of the most commonly used co-enzymes in various bodily functions, including the promotion of wound healing.

Both the silver and silver-zinc topical agents showed equal antibacterial properties. We used the 1% silver zinc sulfadiazine cream on 236 burn patients with satisfactory results before it was widely used. At the present time it is still being used in our unit, being also a good stimulator of granulation tissue growth. For example, when we used it on deep dermal burns after the removal of the burn eschar, or on moderately deep second degree burns which can heal with epithelialization, it would take a little longer for the wound to close, and more prominent hypertrophic scar could result. Thus silver-zinc sulfadiazine seemed to be more appropriate for big traumatic wounds, deep dermal wounds after eschar debridement, or even wounds after debridement of massive necrotizing fasciitis of the extremities and trunk[8,10,25,26,27].

Another topical antibacterial wound dressing which we developed and used for general surgical wounds or superficial burn wounds, and even for donor site dressing, was a multilayered fiber sheet, usually used as cold paper sheets in restaurants. We impregnated the sheets with 0.1% neomycin and 0.1% polymyxin and placed them in an envelope for sterilization. This dressing was quite cost-effective[44,46].

Let me briefly review the composition and regimen of some often-used fluids for the initial resuscitation of burn shock patients, and my modifications used in our burn unit[3].

1) Evan's formula, 1952. In the first 24 hours, Normal saline + Colloid (Albumin) 1mL/Kg/%TBSA,

and 2000 ml of 5%D/W.

2) Brooke's formula, 1953. In the first 24 hours, Lactated Ringer's solution 1.5 mL/Kg/%TBSA + Colloid (Albumin) 0.5 mL/Kg/%TBSA; the second 24 hours switch to D5W 2000 mL.

3) Parkland formula, 1968. In the first 24 hours, Lactated Ringer's solution 4mL/Kg/%TBSA; give half in the first 8 hours, and remaining half the next 16 hours.

4) Modified Brooke, 1979. In the first 24 hours, Lactated Ringer's solution 2mL/Kg/%TBSA; give half in the first 8hours, and remaining half the next 16 hours.

5) Monafo, 1968. Use hypertonic saline solution (HSS) in the first 24 hours: 250 mEq Na + 150 mEq lactate + 100 mEq Cl. Rate given adjusted to hourly urine output.

6) Chomchark's modified formula, 1973. HSS was prepared by adding 80 mL Sodium bicarbonate (containing Na and Bicarbonate, 70 mEq each) to Lactated Ringer's solution (LR) 1000 mL raising the Na content up to 200 mEq/L (a little more than one liter). In the first 24 hours, give HSS at adjustable rates to maintain adequate hourly urine output for the first 8 hours, and give LR for the remaining 16 hours, also at rates allowing adequate hourly urine output. On average the adult would receive 40 to 50 mL/hr. In children less than 30 kg BW, the hourly urine output should be at least 1mL/kg/hr, for adults, 0.5 to 1 mL/kg/hr. My idea for this formula derived from my desire that burn patients not receive too much Na, but conversely not to have hyponatremia, as we have seen burn patients developed severe generalized edema. Thus our burn patients who received our fluid preparation showed less edema and less hypernatremia. You might notice that all of the above formulas have been in use for many years, and remain unchanged, including the Parkland formula which consists of little sodium (130 mEq/L) and which about 60 to 70% of burn centers in the United States still use, especially for burns of over 50% TBSA. The evidence shows that 24 hours after burn patients receive LR, generalized edema would develop requiring prolonged respiratory support, and some patients even develop compartment syndromes leading to unnecessary or preventable escharotomy and fasciotomy. Professor Baxter, who pioneered the Parkland formula, passed away several years ago. If anyone, particularly senior surgeons who had ever been a past student or colleague of Professor Baxter, should attempt to correct his formula to help reduce resuscitative edema or fluid creep, I think Professor Baxter's soul would rest in peace and would probably be very proud and happy for his students, as well as for burn patients. You will also notice that a minority of burn centers or units still give colloids or albumin during the first 24 hours of burn injury, causing considerable harm. We allowed this to happen by negligence and paying them no attention[1,5,6,7,9,17].

Summary and hopes for the future

In the era of high technology, silver-based topical anti-bacterial agent, such as 1% silver sulfadiazine, swung towards high-tech nanocrystalline silver, which can fragment into very small particles and appeared to have better antibacterial and anti-inflammatory properties, leading to better wound healing. An example of this was the "Acticoat", a Smith and Nephew product.

After the failure of using keratinocyte cell cultures as a practical wound coverage, a "neodermal" culture was used successfully as a skin substitute, trademarked as Integra in the United States. However, this skin substitute still needed a very thin layer of skin (epidermis) from the patient to cover over the neodermis. I hope in the near future that a "neoepithelium" combined with a neodermis would be developed as a complete skin substitute.

One medical device which surprised both my colleagues and I was an equipment for burn wound debridement called the Versajet Hydrosurgery System which allowed for a steady working environment with less trauma, less bleeding, and probably a shortening of the duration of operation. This device was also manufactured by Smith and Nephew. Indications for the use of the device should depend on the benefit each individual patient would receive as opposed to the cost of the device.

The environment of the burn unit was one of the most important factors that could contribute to better or worse outcomes for burn patients due to infection and the stress induced by that environment; this included the caregivers as well. Thus burn patients should be admitted to areas isolated or separated from other patients, in particular the burn unit or burn center should be isolated from other wards and burn-

related professionals such as burn nurses, and most burn equipment and devices should also be isolated from others.

In 2010 we opened our new well-equipped Burn Unit, the environment of which we attempted to make pleasant, looking very nice and all, for both burn patients and personnel, especially for doctors, nurses and related professionals who were to work inside the unit. In this new burn unit, no more than 10 patients at any one time were to be admitted, except in the rare occasion of burn mass casualty. The interval between the opening of the first burn unit (in 1978; see above) and the opening of the most recent one (2010) saw some changes in the structural organization of the unit, now with patients separated and isolated in their own rooms. The rules of infection prevention and infection control were strictly complied with. I would think and hope that the morbidity and mortality rates of our burn patients will gradually lessen and finally becoming minimal.

More recent developments in trauma management have been applied in our trauma service, as for example in severe liver injury where many surgical approaches could be used according to the severity of injury, the anatomical nature of the injury, as well as the hemodynamic status of the patient. We have employed simple closure of the bleeding lacerated liver, hepatic resection for a part or lobe which seemed to be multiply lacerated or with unsalvageable liver tissue damage, and right or left portal vein ligation when necessary. In some cases we had to put a shunt into the vena cava when retrohepatic vena cavaI injury with massive bleeding was suspected. Esmarch compression could be used in some cases of severe bleeding from a fractured liver, and packing a massively bleeding liver in the unstable patient, or even performing hepatic artery ligation in selected cases, and so on. Some of our experiences have been described in clinical studies of multiple injuries of the intra-abdominal organs, starting with our analysis of 645 cases of blunt and penetrating injuries of the abdomen. My major interest has always been to promote and expand the use of new, advanced and effective procedures and management of trauma and burn patients to provincial hospitals by encouraging doctors and nurses and related health professionals in those areas who worked on and took care of trauma and burn patients to gain more advanced knowledge and skills. Thus my colleagues and I decided to organize a group of speakers to visit these provincial hospitals in various regions around the country, and at regular intervals. Later we decided to establish several special interest societies of related professionals, including the following.

1981: We established the Association of Trauma of Thailand, led by Professor Phisith Viseskul serving as our first President, with me working as Secretary of the Association (1981-1992);

1985: We founded the Society of Parenteral and Enteral Nutrition of Thailand (SPENT);

1992: We founded the Thai Society of Burn Injury (TSBI);

1995: We founded the Parenteral and Enteral Nutrition Society of Asia (PENSA);

2005: We founded the Thai Society of Wound Healing (TSWH);

2015: I was Honorary President of TSBI and TSWH, which have jointly become the Association of Burn Injury and Wound Healing of Thailand (ABI & WHT).

I had the occasion to serve as President of each of the above societies for some years, before finding a new President to replace me. Each society has its own annual academic conferences. At present, all these societies remain active, fulfilling their mission to great satisfaction[47,48].

Final Remarks

Before ending, I would like to share a story. I was participating in a symposium on "Wound Care in Developing Countries", and this was one of several symposiums in the second World Union of Wound Healing Societies (WUWHS) Meeting held in Paris, France, in 2004. There were about 6000 participants. I was one of three speakers from a foreign country invited by Professor George Cherry, a wound expert from the University of Oxford acting as moderator, to speak at the symposium. My talk covered most of my innovations essential to wound care, and while we did not discuss other equally important matters, the symposium was uneventful and was well-received. Not very long afterwards I saw my CV which I had previously sent to Professor George Cherry, published in the Oxford Bulletin. And following that I was bestowed A LIFETIME ACHIEVEMENT AWARD at the World

Congress of Arts, Sciences, and Communications, in Cambridge, England, in 2009. A few months before this I received A DISTINGUISHED SERVICE AWARD from the International Biographical Centre, Cambridge, England, in 2009 as well. Recently, the International Biographical Centre (IBC) invited me to receive a Research Professorship Award at the International World Congress of Arts, Sciences and Communications held in Edinburgh, Scotland, in August 2015, but unfortunately I was unable to attend due to my health problems, and informed the IBC to send the Award to me by mail.

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