volume and full expansion of the lung, all done to improve oxygenation. Prevention of wet lung by these measures was stressed.

Another important measure recommended was the early establishment of positive pressure ventilatory assistance when wet lung is suspected from the type of injury or when pulmonary insufficiency appears to be developing. It was strongly recommended that blood gas determinations be made available since repeated observations have shown that systemic oxygenation is depressed far below that suspected by clinical observation. Other measures recommended for treatment of established wet lung consisted of phlebotomy when overtransfusion was suspected, digitalization, use of dextran when intravascular coagulation or sludging is suspected and heparinization in those cases in whom fat embolization is suspected.

In the well established case of wet lung it is considered mandatory to change from the Bird or Bennett type of respirator to a volume actuated respirator.

Also when using pressure activated respirators it is important not to utilize oxygen for nebulization because of the known ill-effects of giving high concentrations of oxygen under positive pressure. Changes in the alveolar membrane and pulmonary edema can result. In reported cases, a clinical state not unlike wet lung can develop. Thus the patient with ventilatory deficiency but good lung compliance can potentially be made worse by overvigorous respirator treatment.

The most important impressions gained from the discussion of this perplexing problem were that careful recording of all clinical and laboratory data in such cases is mandatory, that every effort be made to reduce complexity by not tagging patients with the wet lung diagnosis in highly questionable cases, that post-mortem confirmation of all changes in patients dying of pulmonary insufficiency is necessary and that further research and study are required.

It was strongly recommended that this entire subject be reviewed at succeeding conferences.

LATE COMPLICATIONS:

The most frequent late complications are: recurrent pneumothorax, empyema, and clotted hemothorax. Information from the previous report indicated that 137 patients of 629 patients seen at US Air Force Hospital Clark had a pneumo- or hemothorax on arrival. Thirty-one (22.6%) of these patients had a tube in place which was not functioning properly, 58 (42%) had previous treatment with a tube which had been removed prior to air-evacuation. The time of tube removal prior to evacuation was less than 24 hours in 10 cases, 24-48 hours in 8 cases, 48-72 hours in 10 cases, and over 72 hours in 30 cases. Recommendations made at the previous meeting to avoid this problem consisted of the following: Keep the patient at least 72 hours or more after the chest tube had been removed, make an

x-ray evaluation just prior to the flight irrespective of the timing of chest tube removal, and if air-evacuation is required while a chest tube is in place then the Heimlich valve should be utilized. This policy had been carried out in nearly all hospitals in Vietnam over the past few months and a significant reduction in delayed pneumothorax and hemothorax has resulted. Statistical followup was not available however and it was strongly recommended that all PACOM hospitals receiving thoracic injury patients collect this information for presentation at the next meeting.

Empyema is seen in very few patients. Standard treatment methods consist of closed tube drainage, then conversion to open drainage. Observation from Army hospitals in Japan revealed that this method of treatment had been successful in the majority of cases.

Recent observations indicate that clotted hemothorax requiring decortication is decreasing in frequency. Again however, statistical observation is required. In cases where decortication is required it is performed approximately two to three weeks post-injury. Army hospitals in Japan had been using vigorous chest wall physical therapy and measures to improve lung expansion for all thoracic injury patients. In some of these patients where there is x-ray evidence of the remains of a clotted hemothorax, remarkable improvement in the appearance of lung expansion on chest x-ray has resulted from these measures. Nearly all patients had been followed with serial determinations of pulmonary function and these improvements have been documented. Decortication has been avoided in many patients in whom the chest x-ray and physical examination of the chest originally indicated that it might be required.

Another late complication that has been observed is the resolving lung hematoma which excavates to cavity formation. All clinical experience to date indicates that conservative management and prolonged followup will result in eventual healing in most cases. In about 20% of patients the cavityis persistent however, and symptoms such as cough or fever require surgical correction. In these instances following evaluation by bronchoscopy and bronchogram, lung resection of the appropriate amount of involved tissue is indicated. The usual operation is lobectomy.

STATISTICS:

The report of 629 patients seen at Clark Air Force Base and presented at last year's proceedings is included. In these 629 patients from statistical evaluation of the medical records, 78% had treatment with chest tubes, 10% required thoracotomy, 7.2% required no treatment, only observation, 4.5% received thoracentesis, and 0.5% had pericardiocentesis.

Recent reports were available from the 45th Surgical Hospital and from the USARV Surgical consultant on a small group of thoracic injury patients totalling 235. Approximately 87% were managed conservatively and approximately 13% required thoracotomy. Of the 31 patients requiring

thoracotomy, utilizing the chest wall wound or an extension of the chest wall wound was done in 12 and formal thoracotomy was required in 19. Thus formal thoracotomy was required in only 8% of this small group of patients.

Of the 31 thoracotomies reported the following indications were present: control of hemorrhage from chest wall 9, resection of lung 6, debridement and suture of lung 5, repair of major vessels 2, repair of cardiac wound 4, closure of the diaphragm 3, and decortication 2.

Of the 6 pulmonary resections reported there was 1 pneumonectomy, 2 right lower lobectomies, and 1 each of resection of the left upper lobe, left lower lobe and right upper lobe. The 2 major vessel repairs were of the superior vena cava and the pulmonary artery. The following cardiac wounds were repaired: right atrium 2, right ventricle 1, and left ventricle 1. In three cases, closure of the right diaphragm at the time of laparotomy was not possible and a separate limited thoracotomy was performed to accomplish this purpose.

CONCLUSIONS:

Chest tubes are generally better for drainage of the pleural cavity than is thoracentesis. Chest tubes should be used frequently even in forward locations for venting of the pleural cavity. The chest wound should not be used as the site for tube placement. This more frequent use of chest tubes does not lead to an increased incidence of empyema. The Heimlich valve should be used in place of underwater seal drainage during all stages and phases of evacuation. The valve should be replaced by underwater seal drainage and suction when the patient reaches a hospital environment. Immediate suction drainage should be applied to the chest tubes when the patient is undergoing initial hospital treatment.

Conservative but vigorous resuscitation and careful attention to all details of improving pulmonary ventilation is the rule in managing thoracic injury patients. Thoracotomy either of the limited or formal variety is required in very few patients.

Limited thoracotomy utilizing the chest wall wounds for access to the pleural cavity is quite acceptable.

Chest wall defects should be repaired without the use of foreign material and by shifting muscle flaps when required.

Following closure of the pleural cavity and chest wall, it is generally recommended that the skin and subcutaneous tissues be left open for delayed primary closure. Primary closure is acceptable in small clean wounds and complete closure of separate formal thoracotomies is acceptable.

Thoracoabdominal wounds are accompanied by very high rate of abdominal and pulmonary complications. Careful postoperative evaluation is absolutely essential to uncover these complications early.

The incidence of unresolved or recurrent pneumothorax or hemothorax at the PACOM hospital level has been reduced. The rule of not evacuating chest injury patients for 2 to 3 days after chest tube removal and obtaining x-ray evaluation prior to air transportation is of great importance in reducing complications during aerial transport of patients.

Vigorous physical therapy and careful attention to increasing pulmonary ventilation in the convalescent period will yield universally excellent results. Serial determinations of pulmonary function have proven their worth in monitoring improvement of pulmonary ventilation. These measures which are valuable in all thoracic injury patients will also reduce the requirement for decortication in the patient with a small clotted hemothorax. Decortication and empyema have a low incidence under the present regimens of treatment.

The most significant, serious and perplexing problem in the management of thoracic injury patients has been the wet lung syndrome. The lack of definition of the term, multiplicity of etiological factors, lack of a true understanding of the patho-physiology, unexplained clinical courses in various patients with the condition and ineffectual treatment in well established cases are all cause for great concern. Detailed recording of clinical observations, monitoring of physiological parameters including blood gas determinations, full analysis of post-mortem changes in these lungs, and additional clinical and laboratory research will be required before this mystery is unraveled.

GENERAL SURGERY

INTRAABDOMINAL INJURIES

GENERAL:

There was no report of any significant problem in the management of injuries to the stomach. Gastrointestinal bleeding as the result of stress ulceration following trauma to other parts of the body is frequently encountered. There were reports of complications associated with trauma occurring in the left upper abdominal cavity. Injuries resulting in splenic, pancreatic, kidney and liver surgery and injuries to the splenic area of the colon frequently were complicated by left subdiaphragmatic abscesses.

Usually, multiple Penrose drains have been placed in the left upper quadrant of the abdomen following surgery to these various organs. However, these drains all too frequently are brought out through a tiny stab wound so that drainage of fluid collections is impossible. Also, the drains are frequently not moved or advanced for several days so that drainage is not encouraged. Consequently, subdiaphragmatic abscesses occur more frequently than they seemingly should.

It was the consensus of the group that sump drainage would probably more effectively drain this, and other areas, and result in fewer complications. If sump drainage is not possible, certainly the Penrose drains must be brought out through an adequate drainage incision and must be advanced or moved frequently, preferably at daily dressing changes to insure that they do not act as a plug.

In injuries involving the kidney, dependent drainage must be accomplished through the posterolateral abdominal wall and not transabdominally. Pus and fluid do not readily flow uphill.

LIVER INJURIES

Presentation of experience in the management of liver wounds from the combat area with follow-up reports from PACOM hospitals and from CONUS hospitals made up the background material from which final recommendations were made.

The principles involved in handling liver trauma include adequate drainage, suture for hemostasis, resection of devitalized tissue and decompressive drainage of the biliary tree. In general, all liver wounds should be afforded adequate, dependent drainage, which includes a large drainage incision situated as far posteriorly as possible. The use of sump drains is recommended in hepatic trauma of any significant magnitude.

Suture of liver substance is primarily to secure hemostasis and stop biliary leakage. Care should be taken not to suture the liver capsule over an intrahepatic cavity, which could provide a setting for future hepatic abscess or hematobilia. Devitalized liver tissue should be debrided and in more severe cases this may approach the point of total hepatic lobectomy. T-tube drainage of the common duct is recommended in the more severe cases of hepatic trauma to decompress the biliary tree and lessen the likelihood of biliary fistula formation.

There were three main degrees of liver wounds reported. The first of these was that of wounds created by low velocity fragments which penetrate the substance of the liver. These wounds usually present with minimal to moderate bleeding with minimal anatomic disruption of the liver. These wounds were usually treated without specific local treatment except external drainage, although suture for hemostasis and debridement of devitalized wound margins was employed when indicated. It was the general consensus that this type of wound did not present particular problems of management nor of follow-up. Drainage from the wound area was generally advised but T-tube decompression of the biliary system was not felt to be required here.

The second type of wound was one which was more severe and due to either low velocity fragments or high velocity missiles with shattering of the liver parenchyma and hemorrhage of a moderate to severe degree. Some of these wounds may be controlled with conservative measures, such as local mattress suturing and ligating of exposed vessels within the wound. T-tube bile duct decompression and drainage of the wounds were required. It is in this type of wound that the judgment of the surgeon is needed to decide whether hepatic lobectomy will be necessary to control the hemorrhage. As a sub-group in this second type of moderate liver wound is the high velocity missile wound through the lower right chest in which the dome of the liver is sometimes involved. Exposure of the diaphragm for its repair is essential to prevent a pleural fistula. In a few instances a limited thoracotomy is necessary to effect repair of the rent in the diaphragm.

The third type of liver wound is usually that of a high velocity missile with shattering or maceration of liver substance, perhaps with almost complete transection of the liver. This is always associated with severe hemorrhage. It is apparent when the wound is first evaluated that partial hepatectomy or lobectomy will be required. It is this type of case that taxes the skills of the entire surgical and anesthesia team until such time as the severe liver hemorrhage is controlled. Mortality is consistently high.

The following guidelines were discussed as aids in the performance of extensive partial or total hepatic lobectomy:

1. The midline abdominal incision should be converted to a thoracoabdominal incision to facilitate exposure and break the negative

intrathoracic pressure, thus minimizing the risk of air embolism from torn hepatic veins. It must be remembered that cutting the costal arch often results in a painful disability.

2. Control of hemorrhage during resection can be facilitated by the use of hepatic inflow occlusion, which can be safely performed for 15 minutes in the normothermic patient or up to one hour under hypothermia. This allows individual ligation of the biliary vessels and ducts.

3. The line of liver resection should be at the edge of devitalized tissue. Total hepatic lobectomy is necessary only in severe cases.

4. The use of a cyanoacrylate spray to control bleeding from the raw liver surface is still in an investigational status and is not recommended for widespread use.

5. The use of packing to control liver hemorrhage is not recommended except in extreme circumstances.

DUODENAL AND PANCREATIC INJURIES

The experience of all three echelons of medical care, the combat area, the PACOM hospitals, and CONUS hospitals, was reviewed and formed the basis of the recommendations in this report.

DUODENUM:

The recomended treatment for duodenal injuries is:

1. Simple closure in small penetrating wounds without extensive injury to the duodenum or surrounding structures.

2. Resection and primary anastomosis when there is more extensive damage to the duodenum if it is technically feasible.

3. Serosal patching as a definitive procedure initially or when other forms of treatment cannot be safely utilized.

4. Pancreatoduodenectomy can be used for those severe injuries in which the duodenum and pancreas are so severely injured that no other form of therapy is feasible.

5. If extensive loss of the distal duodenum precludes the reestablishment of continuity, Roux-Y anastomosis with the jejunum should be considered.

The majority of duodenal wounds which result from penetrating injuries of the abdomen are associated with other organ injury; principally stomach, liver, vena cava, pancreas and kidney. For this reason it is mandatory to examine the duodenum in all penetrating wounds of the upper abdomen to avoid missing this injury. Before simple closure is accomplished, the duodenum should be mobilized by Kocherization and examined completely to keep from missing a perforation of the posterior wall. The high incidence of associated organ injury also accounts for a number of complications which occur with this injury.

There were 19 duodenal injuries in 643 penetrating wounds of the abdomen presented from Japan. The complication rate in these 19 injuries was 36.8% (7 of 19), and consisted mainly of infection. These infections were subphrenic abscess, retroperitoneal abscess, pancreatic abscess, wound infection, and septicemia. One duodenal fistula occurred in this group and was related to infection.

Resection and anastomosis was associated with the lowest complication rate and simple closure with the highest complication rate. The one Whipple procedure was successful and without complication.

Because of the large number of complications which were related to infection and the large number of associated organ injuries which occurred in these patients, adequate posterior dependent drainage with sump tubes or Penrose drains is strongly recommended.

Serosal patching, although it was not used frequently, was discussed at some length and the opinion was expressed that this might prove to be an excellent method of handling these injuries. It was pointed out that when serosal patching with adjacent small bowel is used the sutures placed in the duodenum should be away from the edge of the perforation in normal duodenum to prevent subsequent breakdown and leakage.

PANCREAS:

The treatment of pancreatic wounds recommended by the study group is:

1. Debridement and drainage of the pancreas in those wounds not associated with extensive damage or disruption of the major pancreatic ducts.

2. Suture and drainage for those injuries in which there is a small tear of the pancreatic capsule without disruption of the major pancreatic ducts.

3. Resection and drainage for injuries in which there is maceration of pancreatic tissue, transection of the pancreas, or disruption of the major pancreatic ducts.

4. Pancreato-duodenectomy in those patients with such severe damage to the head of the pancreas and duodenum that no other procedure is feasible.

The pancreas should be examined in all penetrating wounds of the upper abdomen and, when injury is suspected, the gastrocolic omentum should be divided so that the entire pancreas can be visualized.

Twenty-one pancreatic injuries were reviewed and the major complications discussed. Once again, as with duodenal injuries, infection accounted for the majority of complications and most of these could be attributed to inadequate drainage. The infections consisted of subphrenic abscesses, retroperitoneal abscess, intra-abdominal abscess and wound infection. There were two pancreatic fistulas. Both were associated with simple drainage as the only method of treatment and are probably the result of overlooked damage to major pancreatic ducts.

The highest complication rate occurred with suture and drainage. In these patients resection would probably have been a better procedure.

DUODENUM AND PANCREAS

The lowest complication rate was associated with drainage alone and usually represented the more minor wound. Resection and drainage was associated with only a slightly higher complication rate than drainage alone although the extent of injury was more severe.

It was the general consensus of the group that the two most important concepts in the management of pancreatic wounds are to remove all devitalized tissue and drain the remaining pancreas adequately with sump drains. It was felt that Penrose drains were inadequate and that sump drainage should be utilized in all cases unless there is some definite contraindication to its use. If the infection associated with pancreatic wounds could be eliminated, the majority of complications would be eliminated.

SMALL BOWEL INJURIES

Wounds of any portion of the small bowel require inspection of the entire bowel to avoid missing small, single perforations. Small penetrating wounds may be closed in the usual fashion; however, multiple wounds and those with destruction of small bowel tissue within a relatively short segment are best managed by segmental resection and anastomosis rather than multiple separate wound closures.

Thorough evaluation of mesenteric blood supply is mandatory prior to closure of the abdomen. Single loop vessel injuries may be ligated. However, multiple vessel damage and large areas of hematoma must be carefully evaluated and if there is a deficient blood supply to a portion of the bowel, resection and anastomosis at viable levels is mandatory.

RIGHT COLON WOUNDS

The report of last year's conference on this subject was reviewed. Data concerning the morbidity and mortality of right colon wounds treated during the past year were reviewed. There was agreement that the general precepts set down last year were still valid and required no significant change. Therefore, these recommendations are restated:

A. Wounds of the cecum and ascending colon are essentially the same as small bowel injuries and can be treated in the same way. They fall into the following four categories:

1. Small penetrating wounds, 1 cm or less, may be debrided and primarily closed by sutures after examination of the retroperitoneal space has been completed. No cecostomy is necessary.

2. Large or multiple wounds which do not involve the mesentery and which are not associated with severe contiguous organ injuries or with gross fecal contamination may be treated by resection and ileo-ascending colostomy. Care must be taken that the blood supply through the ileo-cecal branch of the superior mesenteric artery is not compromised.

3. Large or multiple wounds with severe associated injuries or those involving considerable gross fecal contamination and contiguous organ injuries such as kidney, ureter, liver or the duodenum may best be treated with ileostomy and distal mucous fistula. All ileostomy stomas should be matured and be of sufficient length to prevent retraction beneath the skin.

4. Exteriorization of the cecum or ascending colon may be used but is not the procedure of choice because of the mechanical difficulties encountered postoperatively. It should be used only when, in the judgment of the surgeon, the previous three methods are not feasible.

B. Miscellaneous but associated problems which are often a consideration:

1. Lesions of the right iliac fossa associated with right colon injuries must be adequately debrided to include the fracture of the pelvis.

2. All types of wounds of the ascending colon should have adequate exploration of the retroperitoneal space to rule out additional lesions of the large bowel, kidney, ureter, or other retroperitoneal tissue.

3. All patients with right colon injuries should have antibiotic coverage using either Penicillin and Streptomycin or Chloramphenicol.

4. Penrose drains must be utilized to freely drain the area adjacent to, not directly on, the anastomotic site in order to minimize abscess formation and to establish good external drainage should the anastomosis break down. This drainage must be accomplished through an adequately large incision in as dependent a portion of the flank as possible. Sepsis is the primary complication.

5. Multiple intraperitoneal abscesses require drainage and release of matted dilated small bowel. The Baker tube is again recommended for consideration during the treatment of the complication of intestinal obstruction.

TRANSVERSE AND LEFT COLON INJURIES

The principles of management of combat casualties with wounds to the transverse and left colons are well established and generally well followed. Nevertheless some patients were reported wherein smaller lacerations to these areas were treated by primary suture repair and returned to the peritoneal cavity without decompressive colostomy. Other lacerations were primarily repaired and then the injured area was exteriorized without being opened as a colostomy.

It is reemphasized that with the exception of certain right colon injuries, as discussed previously, all colon lacerations must be either:

1. Repaired and returned to the peritoneal cavity with a proximal decompressive colostomy (loop or otherwise) being performed at the time of the initial surgery, or

2. The traumatized area of the colon must be exteriorized as a colostomy.

In either case the colon must be opened as early as practical to afford decompression. This can usually be safely done within 48 hours after operation. The absence of a decompressive colostomy is an invitation to disaster in the forms of anastomotic leaks and generalized peritonitis and a high mordibity and mortality rate.

EXTRA-PERITONEAL INJURIES

A. Retroperitoneal injuries generally involve multiple organs and present difficult problems in management. In caring for such wounds, the following recommendations are made:

1. Preop IVP - to assess bilateral involvement and function, if blood pressure above 80.

2. Perforating trunk wounds should probably have exploration and debridement of the back wound prior to abdominal laparotomy whenever possible.

3. Explore retroperitoneal area by reflecting the gut - check visually and manually.

a. Right side: Check head of pancreas, duodenum, vena cava, superior mesenteric artery, kidney, ureter, and posterior musculature.

b. Left side: Tail of pancreas, transverse duodenum, aorta, inferior mesenteric vein, kidney, ureter, and posterior musculature.

B. Kidney:

1. Debride adequately to include nephrectomy if necessary.

2. Close cut surface of capsule if possible. Mattress suture closure; cut-end is second choice.

3. Assure free urine drainage if kidney, pelvis or ureter is injured.

4. ADEQUATE DEPENDENT DRAINAGE IS MANDATORY.

C. Ureter:

1. Proximal urinary diversion (pyelostomy, nephrostomy).

2. Ureteral anastomosis with splint.

3. ADEQUATE DEPENDENT DRAINAGE.

4. Note presence and location of all stents in the clinical record.

5. Interval post-wounding IVP recommended to rule out subsequent ureteral or renal necrosis. IVP schedule should be noted on flight tag.

D. Bladder:

1. Adequate debridement with two-layer cat gut closure with suprapubic cystostomy and catheter drainage.

2. Cystostomy

a. Do not permit exit thru bladder wound.

b. Separate stab wound is preferable and suprapubic tube should be midline with adequate soft tissue interposed to protect symphysis pubis.

c. Drain space of Retzius.

E. Peritoneal Wounds Involving Trigone and Bladder Neck:

1. Cystotomy with suprapubic drainage is mandatory.

2. Foley catheter - medium size - for uretheral splint without primary uretheral repair.

3. With injuries to urethrocystic junction, a Foley catheter with a large bag (30 cc or 60 cc) is inserted and very mild traction applied. Urethrocystic apposition is best achieved thru use of heavy sutures passed thru bladder neck remnant and tied over perineal bolsters.

4. The perineal wound must be debrided and left open.

5. Diverting colostomy must be considered.

F. Urethral Wounds

1. Penile corpora wounds should be debrided and may be left open or the fascia closed loosely.

2. Penile uretheral wounds should be splinted with a Foley catheter.

3. Membranous urethral injuries should not be repaired but should be bridged by Foley catheters of medium size.

G. Extraperitoneal and rectal injuries

1. Digital and sigmoidoscopic examinations (either before or during surgery).

2. Laparotomy is mandatory. Divided diverting colostomy is mandatory.

3. Distal colon segment must be evacuated.

4. Debridement and primary closure of colo-rectal wound (preferably with mono-filament or gut suture).

5. Do not construct colostomy in laparotomy incision if at all possible.

6. Free presacral drainage established with coccygectomy and lower sacral segments resection as necessary for drainage or repair of low rectal defect. Do not drain thru bone or wound of entry if possible.

7. Any procedure or wound violating the peritoneal reflection should have presacral drainage.

H. Bony Pelvis:

1. Adequate x-ray evaluation (to include IVP, cysto-urethrogram, etc.)

2. Assure urinary bladder drainage (for diagnosis of GU injury and urinary retention).

3. Assess extent of damage to other systems (especially rectum and GU system).

4. Debridement must be as aggressive as conditions permit. At the time of initial debridement, free bone fragments should be removed.

5. Be prepared for massive bleeding.

a. Ligation of one or both hypogastric arteries may be helpful in establishing hemostasis.

b. Packing of wound may be last resort in control of bleeding.

6. Redebridement in a few days may be necessary.

I. Pelvic Wounds involving the hip and acetabulum:

1. The pelvic wound or fracture should be exposed through the pelvis and the hip joint through a formal posterolateral hip joint incision, which is left open after debridement.

ANTIBIOTICS AND INTRA-ABDOMINAL SEPSIS

Antibiotics regardless of number or combination employed are no substitute for adequate debridement, fecal diversion (where necessary) and proper drainage.

In cases with widespread fecal contamination of the peritoneal cavity removal of formed feces and copious saline lavage of the abdominal cavity should be carried out. Addition of antibiotics to such lavage fluid may be employed but the hazards of respiratory depression, acute tubular necrosis and other idiosyncratic reactions should be weighed against possible benefits.

Antibiotics should be begun as soon as possible after admission to the initial treatment facility in those patients with injuries obviously requiring surgery for treatment of traumatic wounds.

Penicillin and Streptomycin or Penicillin and Chloramphenicol are the two most common combinations of antibiotics presently in use in Vietnam for postoperative treatment. Some gram negative organisms, most notably indole producing Proteus species, may be resistant to the usual dosage level of Penicillin but respond to "massive", i.e., 80-100 million unit/day dosage schedule. Surface infection cannot be adequately treated systemically because of impaired local blood supply and the multiplicity of organisms involved with frequent presence of one or more penicillinase producing species. Such infection often denotes inadequate prior debridement.

To obviate inadvertent, prolonged administration of antibiotics, it is suggested that a discontinuation date ("STOP" order) be included in the postoperative orders. A similar notation should be made on the flight tag when such patients are to be moved.

TREATMENT OF LARGE ABDOMINAL WALL DEFECTS

Large abdominal wall wounds should be thoroughly debrided. If the resultant defect cannot be closed by the rotation of local soft tissue, Marlex mesh may be used even in the presence of contamination. Granulation tissue will form over the mesh which can then be skin grafted. This technique is reported by Drs. Schmitt and Grinnan in the American Journal of Surgery, Vol 113, June 1967, page 825, "Use of Marlex in Infected Abdominal War Wounds." A more practical method for field use is to cover the defect with moist packs to prevent evisceration. Adhesions and granulations will rapidly form directly on the presenting abdominal contents which may then be skin grafted. Other foreign materials, including free fascia lata grafts, should not be used in the contaminated wound. Fascia lata grafts in conjunction with rotational flaps have been used successfully in clean wounds in late repairs in PACOM hospitals. Colostomy in these cases is necessary to keep GI tract deflated.

Large wire figure-of-eight "internal" retention sutures are a common cause of loss of abdominal wall tissue due to necrosis and deep subfascial infections and should not be used. The use of conventional retention sutures in the closure of laparotomy wounds in the field is essential and must be routinely accomplished.

BURNS

I. GENERAL:

Burned casualties in RVN are increasing in numbers and are requiring more and more attention. These burns at the present time are usually reaching a definitive treatment facility by helicopter in less than 40 minutes from the time of injury. These patients are resuscitated and definitive debridement is carried out at this echelon before the patient is evacuated to a PACOM hospital. Most severe burns are reaching the burn center in Japan within 36 hours after being burned.

At the present time the majority of burns from RVN are evacuated to the burn center at the 106th G. H. in Japan. This burn center was established in February of 1967 and since that time has received all burns over 20% TBS regardless of service branch. By centralizing the burn patients a regimen for management which is uniform has been established. Patients can now be better stabilized and the disposition made in a more uniform manner. Those patients with small burns can be treated and returned to duty. The patients with the moderate burn which is all partial thickness can be treated and then evacuated to the hospital closest to his home. Those patients with more extensive burns associated with full thickness skin loss can be further resuscitated and stabilized. When the patient is stable, he can be safely evacuated back to CONUS to the Burn Unit at the *SRU at BGH. At the present time all severe burns are being evacuated to the SRU at BGH by utilizing a special burn flight in which a burn team comes from the SRU to Japan to accompany the burn patient back to CONUS.

In general burns are being treated by debridement and sterile dressings in RVN. After they arrive in Japan sulfamylon therapy is instituted and continued until the patient has healed the burn or he is evacuated to the SRU at BGH.

II. RESUSCITATION:

The principles of resuscitation that are used for any severely injured patient should be followed with the burn patient.

A. Airway: A patent airway must be established. This many times can be done by simple change of position of the head, suction of the nasopharynx, insertion of a nasotracheal or orotracheal airway. The indications for tracheostomy should be applied in burn patients as they are for any other surgical patient. A burn of the face or upper thorax per se is not an indication for tracheostomy.

Indications for tracheostomy:

1. Airway obstruction from any cause.

2. Unconscious patient in whom there is fear of aspiration or a need to care for the tracheobronchial tree.

*Surgical Research Unit at Brooke General Hospital

3. Those patients who sustain inhalation pneumonitis and exhibit signs of inadequate ventilation.

4. When there is concern about the airway in the patient that is going to be air-evacuated.

Tracheostomy should be done electively and under ideal conditions.

B. Fluids: An estimation of fluid requirements is necessary as a guide for treatment in all burns. The Brooke formula is easily remembered and utilized in developing a plan for initial fluid administration. The fluids usually employed, Lactated Ringers, Plasmanate, and 5% D/W, are all available in quantity in Vietnam.

BROOKE FORMULA

First 24 hours:

Lactated Ringers 1.5 cc/kg/% burn*

Plasmanate 0.5 cc/kg/% burn

5% D/W: 2000 cc

1/2 to be given - First 8 hours post-burn; 1/4 - each succeeding 8 hour period

Second 24 hours:

Lactated Ringers 1/2 to 2/3 of above

Plasmanate 1/2 to 2/3 of above

5% D/W: 2000 cc

Except for patients with pre-existing anemia, fractures or external source of blood loss, whole blood should not be administered within the first three days but may be required later in the post-burn period.

Clinical Dextran in dosage of 10 cc/kilo (up to 1000 cc) may be given as part of (not in addition to) the colloid requirement for its anti-sludging effect.

Subsequent to 48 hours post-burn, electrolyte free water is largely required and further salt containing solutions should be administered cautiously.

Dehydration in the later post-burn period is commonly due to large evaporative loss.

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*Use no more than 50% for calculation but be prepared to add fluids in the same ratio in larger burns.

Serum sodium levels above 136 are indicative of such dehydration. Large volumes, 6 to 8+ liters of electrolyte free water per day, may be required to replace such losses.

Osmotic diuretics, mannitol, etc., are usually required only in those patients with large heme pigment loads or those with larger area of burn who do not respond to volumes of fluids in excess of those estimated as required.

C. Urinary Output: The urine output in the first 48 hours post-burn is the best clinical guide to adequacy of resuscitation. When there is an early inadequate urinary output, inadequate volume replacement is almost always the cause rather than renal failure. The urinary output should be maintained at 40 to 80 cc/hour. When the output falls below this level the rate of fluid administration should be increased until the desired urinary output is obtained. When the output exceeds 100 cc/hour the rate of fluid administration should be decreased.

Renal failure when it occurs early can almost always be traced to inadequate volume replacement. In patients with other associated crush injury or in patients who have chemical burns where hemolysis may be prominent, early acute renal failure may occur in spite of adequate volume replacement but it is rare. Renal failure is usually a late complication in burn care and is a manifestation of sepsis.

III. WOUND CARE:

A. Debridement:

Debridement can invariably be carried out in the emergency room or ward and the use of general anesthesia at a time of rapid edema formation and diminished blood volume is decried. Such debridement can be carried out with minimum discomfort using intravenous analgesia.

Devitalized skin should be removed, bullae excised, the body hair shaved from the involved and immediately adjacent areas, and the burned areas cleansed with a surgical detergent. The patient may thereafter be put to bed on surgically clean or sterile sheets. A cradle over exposed burned surfaces with overlying sheet increases patient comfort and provides some protection to the wound.

Immediate dressings are not required but if used should not be circular or constricting.

Elevation of burned hands is imperative.

B. Escharotomy:

May be required in circumferential third degree burns of the extremities or chest (rarely with deep second degree burns). Fasciotomy is seldom required and then only in particularly deep burns involving muscle.

Coolness and edema of distal unburned parts are normal accompaniments of burn injury and are not indications for escharotomy. Cyanosis, impaired capillary filling and progressive neurological changes are indications for escharotomy.

Technique: (1) Incision along mid lateral and/or mid medial lines of extremities and along anterior axillary lines of the chest.

(2) Throughout extent of burn.

(3) Should be carried transversely across joints where subcutaneous "padding" is least.

(4) Whenever possible avoid superficial arteries, nerves and tendons.

(5) General or local anesthesia is not required since incision is through third degree burn.

(6) Incision is carried only through dermis and immediately subjacent thin connective tissue layer - not into fat or through deep fascia.

IV. ANTIBIOTICS:

All burns other than the small superficial partial thickness burn should be given penicillin for the first 7 days post-burn. This is to eliminate infection by B-hemolytic streptococcus which may occur. After this period antibiotics are discontinued and are only given for specific indications of which urinary tract infection, pneumonia, and septic phlebitis are the most usual indications.

WHITE PHOSPHOROUS BURNS

The incidence of acute renal failure following white phosphorous burns would seem to have decreased slightly since last year's conference. Of the 31 cases of phosphorous burns treated in RVN and Japan, only 3 patients were known to have developed acute renal failure. One patient with 35% total body surface burns was known to have received prolonged irrigation of his burns with copper sulfate solution followed shortly by the picture of intravascular hemolysis, hepatic damage, elevated urine copper and acute renal failure as reported in the literature on copper intoxication. He diuresed and survived but had residual abnormalities of liver function when evacuated to CONUS. A second patient differed from the first only in that a definite history of prolonged concentrated copper sulfate irrigation was not present although this solution was used, and he expired. A third patient was felt to have received improper initial resuscitation as the etiology of his acute renal failure. He rapidly expired from pulmonary edema and pneumonia without dialysis.

Initial treatment of these injuries varies with the facility. Use of a 20% solution of sodium bicarbonate for initial irrigation, or, the use of dilute (less than 5%) copper sulfate solution for identification of phosphorous particles is satisfactory. It is to be emphasized that copper sulfate solution is not to be used as a soak or a continuous dressing. Ignited clothing causes a significant proportion of the total burned surface and such burns are treated conventionally. The use of topical lithium solutions is precluded by marked heat of reaction and obnoxious fumes. There is no apparent specific advantage gained from the use of H_2O_2 for irrigation.

RECOMMENDATIONS FOR TREATMENT:

(1) At the first echelon of medical care, lavage with copper sulfate solution followed by wet (water or saline) dressings to prevent reignition of phosphorus particles prior to their definitive removal in a hospital.

(2) Resuscitation in conformity with the standard principles for the management of a burned patient.

(3) Top priority debridement of the areas of phosphorus burns with total removal of phosphorus particles. Removed phosphorus particles should be placed under water to prevent operating room fires.

(4) Continued evaluation of hemolysis and hepatotoxicity of uncomplicated phosphorous burns regardless of percentage of total body surface burned.

(5) Management of acute renal failure by conventional methods with consideration of $AgNO_3$ soaks for local burn treatment rather than sulfamylon.

(6) Routine measurement of 24-hour urine copper and blood ceruloplasmin when copper sulfate is used in initial treatment together with search for previous exposure to other known oxidants.

ORTHOPEDIC SURGERY

Soft Tissue Wound Care

Preservation of life and limb depends upon the wound and the surgeon. War surgery is a demanding experience requiring aggressive and meticulous attention to every detail of patient care under adverse conditions.

The Orthopedic Study Section of the 2nd CINCPAC Surgical Conference is in agreement with the NATO Handbook of Emergency War Surgery's objectives on the care of Soft Tissue Wounds (Chapter XVI) with the following exceptions:

1. When debridement is concluded large blood vessels must be covered to prevent maceration and drying in the wound. Tissue shifts should not be done to cover nerves or tendons in the combat environment. Exposed tendons in the wound, debrided and left open for evacuation, should be covered with a wiped vaseline gauze in order to keep the tendons moist during evacuation. The remaining portion of the wound should be dressed with fine mesh gauze and fluffed gauze.

2. The treatment of infected wounds requires an aggressive approach. This means drainage of pus. Redebridement of necrotic material. Establishment of open wounds with dependent drainage. Initially prophylactic antibiotic coverage should be instituted while one is waiting for culture to determine the organisms and the specific antibiotic therapy required.

In summary, debridement can best be stated as in the following couplet:

Of the edge of the skin
take a piece very thin

The tighter the fascia
the more you should slash'er

Of muscle much more
till you see fresh gore

And bundles contract
at the least impact

Leave intact the bone
except bits quite alone.

Sir James Lermonth

Hand Injuries

A. General Remarks

Priority for hand injuries is low because isolated hand injuries are seen after more lethal problems, and the multiple injured patient has higher priority for injuries other than the hand. This results in a longer time between injury and surgery in the average hand wound.

B. Initial Surgery

1. A tourniquet should be placed and be inflated during debridement of the hand because there is a need for anatomical orientation during debridement. The tourniquet should be deflated after each 60-minute period. A minimal amount of the border of the skin wound should be excised. A wide fascial incision in the longitudinal axis of the extremity is required to visualize the muscle damage beneath. A thorough debridement of the muscle until only contractile, bleeding muscle remains is required. Bleeding vessels are ligated. Only those portions of tendons which are damaged are excised.

2. The nerve seen in the wound or adjacent to the wound, should have its appearance described in the operative report. If the nerve is in continuity, this should be stated. If it is lacerated completely, this should be stated. If there is a partial laceration, this should be estimated in percentage of total diameter.

3. Severe wounds need extension for anatomical diagnosis and fascial compartment release. This fasciotomy during debridement is particularly important with high velocity missile wounds of the forearm and arm. It may be necessary to incise the transverse carpal ligament if the tissues are swollen and there is danger that the median nerve and tendons will be compressed at the transverse carpal ligament.

4. Copious irrigation is indicated.

5. Do not remove bone that has soft tissue attachments.

6. Kirschner wires may be used at the time of initial surgery in special conditions where stabilization of dislocations are required.

7. Don't undermine soft tissues routinely but only when required to visualize the extent of the damage in the wound and complete the thorough debridement.

8. Obtain x-rays in two planes. A dislocation of the proximal end of the first metacarpal has frequently been missed, and this may need a Kirschner wire fixation for stabilization.

C. Dressings

1. Fine mesh gauze dressing should line the wound in a single layer, applied so that wound drainage is not obstructed. The space between is

lightly filled with fluff gauze but not packed. Packing occludes drainage.

2. Plaster splints are used to obtain the functional position of the hand. The functional position of the hand is obtained if the wrist is dorsiflexed 25 to 30 degrees. The splint should extend to the distal palmar crease. It will then be seen that the fingers normally fall into a flexed grasping position. This position is the position of function. In addition, the thumb should be placed away from the hand in the position of opposition. This means the pulp of the thumb faces the pulp of the long finger. In summary then, we have dorsiflexed the wrist, opposed the thumb pad to the long finger pad, and placed the hand in the position for "pinch".

D. Antibiotics

Prophylactic antibiotics are recommended in war wounds. Penicillin in doses sufficient to counteract hemolytic streptococcus are recommended. Broad spectrum antibiotics such as Streptomycin or Chloromycetin may be used as additional prophylactic antibiotic coverage if the physician believes this is required. At the earliest time the wound should be cultured and any specific contaminant be identified in order that sensitivity to antibiotics can be determined.

E. Time of Closure

1. Primary closure of war wounds is not recommended. In fact, this procedure is discouraged based on experience during the war in Vietnam.

2. Delayed primary closure should be done at 4 to 7 days if the wound appears clinically clean.

3. After 10 days the skin edges will become fixed and it may be necessary to cover wounds with split thickness skin graft. In a clean wound this should be done without hesitation because our objective is to close the wound. In some cases the split thickness graft is considered as a wound dressing and in almost all cases will successfully adhere and seal the wound. Mesh grafts are especially effective.

4. Split thickness skin grafts can be laid on in the Bradford-Cannon technique and need not be sutured. This however is the prerogative of the surgeon.

5. Skin pedicles and pedicle grafts of skin should not be attempted in Vietnam. Almost all of these have been observed to fail, either partially or completely.

6. Kirschner wires for stabilization of carpo-metacarpal dislocations or fracture dislocations should be used at the time of debridement if this is necessary to obtain stabilization. If used they should be cut off beneath the skin. Should one be unable to bury the Kirschner wire, the

protruding end should be dressed with cotton and collodion to seal the Kirschner wire tract from outer contamination.

F. Elevation

Elevation of the hand should be continuous until there is no evidence of edema. This requires an average of 3 to 7 days of elevation. This can be done by wrapping the forearm with a pillow or suspending the arm in a gauze or towel sling with the hand 10 inches above the chest level.

G. Exercise

Exercise and active motion of the fingers should be allowed within the dressing and should be encouraged by the physician if the condition of the fingers permits. Pain experienced by the patient should be a guideline as to the degree of active motion.

H. Nerves

1. Do not repair nerves at initial surgery. Experience has shown that early nerve repairs are generally unsuccessful in war wounds in overseas conditions in these times. Even though enthusiastic early reports frequently quote excellent results in nerve suture, long term results in nerve surgery do not bear out the initial early enthusiasm.

2. If a major nerve trunk is seen in the wound at the time of debridement, and this nerve is severed, a small suture should be placed through the epineural covering at the tip end of the severed nerve. This suture should be used to anchor the nerve in the normal location and normal rotation anatomically. Both ends of the nerve should be treated in this fashion. No debridement of the nerve is needed. The purpose of this suture is to prevent passive retraction of the nerve and the resulting increased defect in the nerve which must be corrected at elective surgery months after wounding. Motion of adjacent joints will produce passive retraction of the nerve ends.

3. Do not repair vascular injuries distal to the wrist even though both vessels are involved.

4. Do not repair tendons and do not shift their positions in the war wound at the time of debridement. Further damage to these tissues is likely to occur.

5. Do not shift tissue pedicles or tissue bridges, either skin or muscle, to protect vital structures except a major vessel. These wounds are closed 3 to 7 days later. A complete and thorough debridement should be performed. At the completion of this debridement, with the tourniquet released and the blood circulation and tissues visualized, it is easy to determine any tissue which is nonviable by inspection and further examination. Therefore, preserve all viable tissue at its most distal level.

For example, if amputation of an avascular digit is required it may be possible to save some of the viable skin flaps for future coverage on the hand.

6. Do not discontinue elevation of the hand during air-evacuation of the patient. Elevation of the arm upon pillows or by wrapping a pillow around the forearm or by suspending the arm in a towel attached to any overhead hook is adequate. The hand preferably should be 10 inches above the chest level at all times.

Foot Injuries

A. General Remarks

1. Because of its normally dependent position, the foot may have impaired vascularity and venous stasis. In the many mine explosion wounds, severe injuries of the foot are seen with multiple embedded small fragments. A blasting wound of the foot from a land mine normally cannot be debrided adequately unless the sole of the foot is approached. Consequently, civilian rules for plantar incisions and scars must be temporarily discarded in favor of adequacy of debridement. Therefore, extension of plantar incision should be planned to obtain the complete and adequate fascial decompression and debridement of the small muscles of the foot on the plantar surface and the dorsal surface. Ordinarily incisions on both surfaces will be required for adequate debridement.

a. Avoid prominent metatarsal heads if this is feasible and allows you to complete adequate debridement.

b. The heel-splitting incision is valuable to debride a severely comminuted and contaminated posterior foot and calcaneus.

c. Extension of the incisions usually can be obtained in linear orientation to the axis of the extremity. This means that the nerves and vessels and long tendon anatomical arrangements are reasonable directions to extend incisions.

2. Closed crush injuries of the foot are serious injuries. For example when vehicles have run over the foot, the foot requires both dorsal and plantar incisions down to the intrinsic musculature to provide decompression of this wound. If this is not done, ischemic necrosis of these muscles may occur.

3. Early elevation and continuous elevated position is essential to counteract the excessive swelling. If these principles are adhered to Volkmann's contracture in the foot will not occur.

4. Penetrating missile wounds of the foot require extensive repeated irrigation at the time of debridement.

5. Do not excise bone which has soft tissue attachment.

6. Use Kirschner wires to stabilize unstable tarsal dislocations. Reduced dislocations will usually redislocate due to muscle pull as soon as the patient awakens from anesthesia.

7. Do not undermine soft tissues in the approach to debridement unless this is required to expose the wounds for debridement.

8. Obtain x-rays in two planes to recognize dislocations. Then reduce them and stabilize them during debridement. Dislocation in the bony arches of the foot usually results in chronic swelling and impairment of circulation and sensation.

B. Time of Closure

1. No primary closure of foot wounds should be performed in wartime surgery.

2. Delayed primary closure of foot wounds may be possible, but if large bone defects are present, large tissue spaces will be present in the contours of the foot. It is not possible to close the skin and eliminate these defects, nor is it possible to adequately drain them to prevent secondary wound breakdown. Therefore, they should be treated as open wounds with progressive dressing changes or as an alternative when clean, a split thickness skin graft can be inserted down into the contours of these deep wounds to achieve tissue healing and wound closure.

C. Dressings

1. Immobilize these wounds in circular casts that are bivalved and the dressings cut down to the skin. Then tape the two bivalved transections together.

2. The plaster slab splint usually applied does not hold the foot out of equinus position and in addition the ace bandages which hold it on create a constant pressure during air-evacuation and may result in pressure sores about the heel and calf. Thick slabs of plaster, wet in hot water and allowed to harden close to the skin, have caused some burns in the posterior calf which have complicated the wound care.

3. Drains should not be used.

D. Miscellaneous

1. Do not repair nerves in the foot.

2. Do not repair tendons primarily.

3. Do not repair arteries distal to the ankle.

4. Do not shift tissue pedicles or skin bridges to cover wounds at the time of debridement. Shifts of skin and muscle in this way are likely to result in further necrosis and complication of wound care. For covering defects, use split thickness skin grafts as wound dressings.

Amputations

A. General

1. In general open type amputations are the accepted procedure in war wounds. Specifically, this means open circular amputation. The skin is incised to the muscle and allowed to retract. The muscle incision is then performed at the retracted skin level. The bone is amputated at the retracted muscle level. Thereafter, bleeding is controlled, wound dressings are applied to the raw surface, and stockinette skin traction is applied. Skin traction using 8-10 pounds over the edge of bed is applied in 4 to 12 hours after the dressings are applied and is thereafter continuous. A tourniquet is kept at the bedside.

2. The many blasting mine injuries seen in Vietnam are causing multiple injuries throughout the extremity. Open circular amputation at the most distal level of good circumferential skin frequently results in unnecessary sacrifice of lengths. For this reason, the modified type of amputation has been used in the mutilated type of extremity seen with land mine injuries. First the entire extremity is completely and thoroughly debrided. When only viable skin, muscle and bone remain, the site of election for amputation is determined by the most distal level of a major viable skin flap, providing that the muscle is viable over the bone at this level. Circumferential skin traction cannot always be applied to this type of a stump and for this reason modified skin traction and anchoring suture procedures are necessary. It is important to consider this type of an amputation as a major open war wound and at the end of three to seven days it can be partially closed with skin graft and the modified skin flaps, or sutured in the most desirable position without tension. The objective in this type of an amputation is to achieve a clean healed wound as quickly as possible. Revision of this amputation should be done at PACOM or CONUS hospitals as an elective rather than an emergency procedure after the swelling and infection has subsided. In practice, the majority of these modified type of amputations following mutilating extremity injuries are closed by a modified skin flaps, plus split thickness skin grafts.

B. Transportation of Amputations

The open circular amputation in stockinette skin traction can be evacuated with traction remaining on the skin by the means of a self-contained outrigger bar formed by the wire ladder splint. In this manner, the patient can be placed in air-evac channels and will not suffer loss of skin length while in transit.

Pelvic Fractures

A. Open

1. Pelvic fractures ordinarily occur from missile fragments or gunshot wounds entering through the upper thigh and buttocks, penetrating the bony pelvic wall and entering the pelvic cavity. They frequently continue and exit through the opposite perimeter of the body. Care of these wounds is a combined General Surgical, Urological and Orthopedic Surgical problem. The wound of the buttock and hip should be handled as any other wound seen in war and not handled as a fracture per se: that is, a formal utility approach to the hip joint should be performed in order to reach the depths of the wound and complete a thorough debridement of bone, muscle, pelvic wall and iliac muscle wherever it is involved. Loose pelvic bone fragments should be removed. The penetrating wound of the pelvic wall should be enlarged with a rongeur. The bladder will be managed as penetrating bladder wound, frequently requiring a suprapubic cystostomy. Ureteral injuries must be managed with catheters and the urinary stream may be diverted through a nephrostomy tube. The colon wounds are treated with standard techniques and a diverting colostomy is usually mandatory. When urinary and fecal contamination and diversion have thus been accomplished, the wound of the hip and the pelvis will heal as any other well debrided war wound will heal. It can then be closed secondarily at 7 to 10 days if clinically clean. Drainage of the deep pelvis may be accomplished by posterior coccygectomy as is well known to general and urological surgeons.

2. If these principles are not adhered to, sepsis, pelvic abscess, peritonitis and septicemic deaths are assured. During the Vietnam war no other form of management has been successful. Morbidity and mortality from this type of a war wound is one of the highest known. If the hip area is painful, the patient may be prepared for evacuation by applying a short plaster boot with a transverse bar attached to prevent the extremity from rolling freely during air-evacuation, or the leg may be simply wrapped to the other leg.

B. Closed Pelvic Fractures

Closed pelvic fractures are handled in a manner similar to those seen in civilian automobile accidents. This requires evaluation to determine that the abdominal viscera are intact, and that the urinary and fecal streams are under controlled management. Bleeding from pelvic fractures is frequently extensive, commonly produces shock and almost routinely produces an adynamic ileus. Treatment then consists of bedrest, sandbag splinting, avoidance of decubitus ulcers, the use of the nasogastric tube when necessary, and evacuation to offshore hospitals when the patient's condition permits.

Wounds of Joints

A. General

1. All penetrating or perforating wounds of joints should have physical examination, x-rays and be followed by a formal arthrotomy to accomplish debridement. If the joint location permits, the visualization and debridement will be far more thorough under tourniquet ischemia.

2. Copious irrigation of the joint following debridement of all deep devitalized tissue should be performed.

3. An interrupted, loose approximation of the synovial joint lining should be performed. Skin closure should not be performed.

4. No drains and no irrigation catheters should be inserted. The wound should then be encased in a plaster cylinder which is bivalved over the surgical dressing. Prophylactic antibiotics, including Penicillin, should be routine. The patient with such a wound can then be evacuated in a few days to have delayed primary closure performed in 3 to 7 days at some other hospital.

5. Closed catheter techniques should be used only as secondary procedures for joint wound care when the classical debridement and synovial closure type previously mentioned fails. It is important that the synovial lining not be tightly closed so that the joint when it effuses can decompress itself gradually.

B. Alternative Procedures

1. If an avulsing wound occurs so that the synovium is destroyed, the capsule may be closed with interrupted sutures and the skin again left open as previously mentioned.

2. Another type of wound of the joint is seen with avulsing injuries where neither synovia, capsule or covering skin is available. Major bony damage may have occurred in the joint. This type of wound must be treated as is any other wound of war by thorough, meticulous debridement and irrigation. It then must be dressed as an open wound with gauze and dry fluff dressing so that the wound is covered with a large well-fitting but bulky absorptive dressing. This is then encased in a circular plaster and bivalved. This type of joint wound then is reinspected in 3 to 5 days at which time if the condition of the wound and soft tissues permit skin flap shifts for coverage or split thickness grafts can be applied to obtain closure of this wound. The salvage rate on this type of a wound frequently does not exceed 25%. However, it is mandatory that this be cared for as any other wound in which one's objective is to obtain a closed healed wound as rapidly as possible.

C. Complications

The attending surgeon must be alert and quickly recognize joint wound sepsis after care by any of these methods previously mentioned. Should

joint sepsis occur, the surgical procedure should be promptly repeated, the joint reopened, redebrided, irrigated and a synovial lining approximation again performed as is used by the classical method. The initial care of joint wounds can usually be managed by these methods. Selective changes in management is the prerogative of the attending surgeon should these previously used procedures fail. This includes the consideration of closed or open wound drainage or catheter irrigation drainage as seems indicated, specific antibiotic coverage, determined by wound culture and sensitivity studies and other intensive treatment procedures.

Treatment of Unstable Fractures

A. General

1. Fractures in war wounds can be managed by manipulation and external casting procedures in almost every case. Use of metallic fixation agents in early care of battle casualties is contraindicated. The care of the wound is of primary importance and closed reduction of fractures and external stabilization methods are almost always possible.

2. During debridement curette and clean bones and leave bony fragments with soft tissue attachments. In addition, large segments of long bone shafts, even though they are not attached to the soft tissues, should be cleaned and left in the wound. If thorough debridement and proper wound care with external splinting is applied with diligence, these wounds will heal in a modified manner. The majority of these wounds can be closed by delayed primary or secondary closure procedures in the off-shore hospital in 3-7 days.

3. Do not close open fractures in war wounds at the time of primary debridement. Tissue shifts should not be done. Dressing of fine mesh gauze should line the wound and be covered with fluff gauze loosely applied to absorb wound serum. This should be held in place with external circumferential dressings in the customary manner. The fracture should then be encased in a circular plaster cast and be bivalved or in special circumstances monovalved. The underlying circumferential dressing should be cut to the skin to prevent constriction of the extremity when swelling occurs. The patient is then ready for air-evacuation if he is otherwise stabilized. The continuing care, surgical reexploration, inspection and debridement of the wounds is indicated at 3 to 7 days with delayed primary closure or if necessary, split thickness graft to close and achieve early healing of the wound. At this time remanipulation and casting will be done.

B. General Evacuation Policy

1. Before evacuation it is wise to evaluate the patient's condition and anticipate any deterioration during evacuation.

2. The patient should be reasonably comfortable, be afebrile and have a hematocrit of at least 30.

C. Special Cases

1. Fractures with vascular injuries. A vascular injury associated with an adjacent long bone fracture can usually be splinted with a circumferential cast which has been bivalved or monovalved. If movement of the fracture is demonstrated to embarrass the circulation at the site of arterial repair under rare and special circumstances, internal fracture fixation may be considered.

2. Transportation of a brachial artery injury is best performed in a chest spica cast with the arms supported across the chest. The operative area should be windowed to permit immediate access to the wound during air-evacuation movement in the event that secondary bleeding occurs.

3. Arterial repairs in the thigh associated with femur fractures may require a body spica. Again it is mandatory that the area of vascular injury be windowed to permit immediate access to this area should bleeding occur during air evacuation.

4. All plaster casts should be marked with the date of injury and a drawing of the underlying essential pathology for easy orientation of those physicians and nurses who care for the patient during evacuation and who may receive him without records being immediately available upon arrival at a new hospital.

D. Hydration and Stabilization

Patients arriving in PACOM offshore hospitals are usually dehydrated, hypovolemic and excessively fatigued. They relax and sleep through the night with minimal medication. During this first 24 hours they are hydrated and blood transfusions administered prior to further surgery. A two year observation period in Japan has shown that this rest, hydration and stabilization period is far more important physiologically than closing the wound one day earlier.

Plaster Casts and Orthopaedic Appliances

A. General

Patients cared for in plaster casts and other orthopaedic appliances must move through air-evacuation channels and therefore their needs during air-evacuation should be considered. The body spica applied for fractured femurs should reach from the nipple to the toes. The uninvolved leg should have a leg extension down to the distal third of the thigh. Transverse bars should pass from the long extremity cast at the knee to the short leg for additional strength. The peroneal areas can be cut out adequately and there must sufficient abduction of the legs to permit use of paper urinals and small flat bed pans as necessary. A pencil drawing on the prominent

surface of the cast preferably over the site of the injury should indicate the area of fracture, the date of injury and date of wound closure if it has occurred. The leg should be abducted only to the degree to which it will fit on a standard litter. With the involved leg flexed at the knee, the patient's leg and cast should be confined to the width of the litter if he is an average sized individual. The reason for this is that in emergency conditions the spica may need to be passed out of an emergency aircraft exit. All these exits are the size of standard litters.

2. The second reason for marking the cast is that the uncomfortable patient who may have a fever and be travelling in air-evac channels can be more easily managed without extensive review of his records should the degree of injury be obvious by cast markings. This simple expedient will enable the physician seeing your patient to make a brief survey and attend to his comfort or his impending complications quickly.

3. All plaster casts in patients being evacuated should be bivalved. This should be performed when the cast is dry and the two bi-valve halves attached firmly together with circumferential adhesive tape. At least one complete roll should pass around the instep, one around the ankle, one around the calf for the short leg cast. For the long leg cast an additional turn should be made at the knee and one at the upper thigh. Large patients may require an additional adhesive tape splint at the mid-thigh. This concept is applicable to body spica casts and circumferential adhesive tape should be placed at the chest, mid-abdomen, pelvis and groins. Plaster casts managed in this way will permit the air-evac crew to decompress the swollen extremity in-flight and will permit immediate emergency access to unexpected bleeding while en route airborne. In special circumstances decided by the attending physician, when strength of the cast is critical the monovalve cast is acceptable.

4. The air-evacuation planes do carry a hand type cast cutter. This will be available but it is time consuming and sometimes cannot be used rapidly enough to prevent hemorrhagic shock.

B. Care of Amputations During Air-evacuations

1. The open circular amputation of the thigh or calf must have a self-contained type of traction applied prior to evacuation. The reason is that the loose swinging weight is so traumatic and bruising to the amputee's stump that it must be discontinued. By contrast, a self-contained traction apparatus is reasonably comfortable and secure throughout air-evacuation movement.

2. Two methods of self-contained traction are common, others are acceptable:

(a) For the thigh amputee, place a short plaster body cast beginning at the lower abdomen and surrounding the hips down to the area adjacent to the amputation site and a short distance on the normal thigh. A wire

ladder splint bent in the shape of a U can be attached to the amputated side and extended beyond the stockinette traction. The stockinette traction can then be tied with a rubber tubing to the wire ladder splint with 8# tension. This will retain skin traction throughout the evacuation.

(b) A second method for thigh amputees is to place the adherent stockinette about the extremity and allow the glue to dry. With the patient supine an assistant then pulls firmly on the stockinette traction apparatus and holds this while a two-layer sheet wadding padding is wrapped from the groin to the amputation border. A circumferential plaster wrapping can then be applied from the groin down to and including the stockinette which is held tense by the assistants. If stockinette is held firmly in traction until the plaster has soaked into the stockinette and has become adherent to it throughout its course a self-contained traction mechanism will occur. This is a quick expedient method of obtaining self-contained traction, but is less efficient and durable than the outrigger-type of plaster cast.

C. Metallic Splints

Use of metallic fixation at the time of debridement in war wounds has led to many complications. Rarely if ever is it indicated and therefore should not be used. If the patient is evacuated through normal channels to offshore hospitals it is the responsibility of the orthopaedic physician who will be reinspecting, redebriding and closing or resurfacing this war wound to decide how the fracture is managed. Experience through many wars and many hospitals in this war has shown that metallic fixations of these war fractures is fraught with complications. Rarely if ever should it be used. If metallic fixation is used it should be only after consultation with a fully trained orthopaedic physician of mature judgment and several years war time experience.

D. Fasciotomy of Closed Spaces

1. A number of instances have occurred and continue to be seen where ischemic necrosis of muscle occurs because of tamponade produced by restrictive circumferential fascial compartments. In several instances, following vascular repair of the brachial artery or following perforated missiles of the forearm, extensive swelling occurred within the volar and dorsal compartments of the forearm. This may occur immediately following the wound but frequently occurs while the patient is in air-evacuation channels and is manifested by pain verbalized by the patient as pain and tightness. Several instances of Volkmann's ischemic contractions have occurred in a two year period. For this reason, incision of fascial compartments should be performed. They should be performed associated with debridement or at any time the need arises. The long flexor muscle bellies of the wrist and fingers should be separated bluntly at their anatomical division points in the midline with proper care of vessels and nerves. The volar interosseous membrane should be visualized to assure adequacy of decompression volarly. An identical procedure should be performed in the dorsal compartment of the forearm. The muscle bellies of the thumb and index finger extensors should be visualized as a criteria of adequate decompression.

These wounds should be left open since they can be easily closed after the swelling process has subsided. This closing or surfacing procedure should be at 3 to 5 days as the patient's condition permits.

2. The fascial compartments of the calf and their relation to ischemic necrosis are well known both from civilian injuries and from vascular repair of the femoral artery. Adequate decompression fasciotomy of the calf can be performed in two ways. The more common type is with an adequate 6" to 8" skin incision over the anterolateral aspect of the calf. The deep fascia is visualized. Extensor digitorum and peroneal muscles identified and the muscles separated down to a depth where the deep peroneal nerve can be visualized. A posteromedial incision is made of approximately 8" in length and located over the medial calf. The gastrocnemius and soleus muscles will appear normal; however, it is essential that the soleus muscle be peeled from the tibia and retracted until one can visualize the posterior tibial muscle adjacent to the interosseous membrane between the tibia and fibula. Only in this wide exposure can decompression of the deep compartment of the posterior calf be assured. These wounds can be left open and closed or skin grafted secondarily in 3 to 5 days. These closures can be performed in offshore hospitals in the evacuation chain. Experience has shown that they close or resurface without difficulty and the calf muscle recovers well following these procedures.

3. The second method of fasciotomy is performed by incising over the middle third of the fibula. The skin incision should be made and should identify the superficial nerves in the area. The fibula then can be cleared by subperiosteal dissection for a distance of 6" and this portion of bone removed. Through the floor of this periosteal incision, incision can be made into the anterior compartment of the calf, into the peroneal lateral compartment of the calf, into the posterior compartment of the calf, specifically to the soleus and gastrocnemius musculature and in addition to the fourth compartment which is the posterior flexors on the interosseous membrane posteriorly. It is only with this type of thorough exposure and fasciotomy that the condition of the flexor hallucis longus, flexor digitorum longus and posterior tibial muscles can be seen, determined to be viable and can be decompressed adequately. These wounds can be closed secondarily in offshore hospitals. These procedures seem radical but none seem radical compared with a ischemic necrosis of muscle compartments of a young man's leg.

Tendon Injuries

A. Summary of Tendon Injuries:

Major weight bearing tendon injuries unassociated with amputations in the immediate area were relatively infrequent. For example, there were five serious lacerations of the Achilles tendon. Four of these were incomplete and one was complete. The triceps and quadriceps tendons injured only with missile injuries in the area and are rarely an isolated injury. In the offshore hospitals at the time of debridement and delayed primary closure, if the wound is ideally clean, these major tendon injuries or major muscle injuries are approximated in continuity so that they will heal during the total wound healing process. This type of surgery is elective, requires time and considered judgment, and is not recommended in a combat area. It should never be done at the time of primary debridement of a war wound.

B. Characteristics of Tendon Injuries in the Forearm:

Tendon injuries in the forearm are caused with equal frequency by multiple shell fragment wounds or gunshot wounds. The volar and dorsal surfaces are equally exposed to such missiles although early in the war an increased tendency for injuries to the dorsal surface was seen. The care of these wounds should be directed to the care of wounded tissues. Debridement should include tissues damaged and not salvageable and which do not have blood supply to sustain them during healing. If the debridement temporizes because one does not like to remove the essential tissues, the debridement will fail, chronic wound infection is assured and more disability to the patient will occur.

Tendon injuries on the extensor surface of the hand are almost always caused by shell fragment wounds. All varieties in combination occurred. The need is to completely debride the hand under tourniquet ischemia. Many cases of temporization and debridement without tourniquet control have resulted in incompletely debrided hand wounds being seen in Japan. This is the reason for the orthopaedic study group recommending the use of the tourniquet when debriding hand wounds. Tendon injuries on the flexor surface of the hand had different characteristics. Rupture of tendon from excess stress on the fingers occurred rarely as a closed injury. Flexor tendon injuries in the palm and fingers were almost invariably due to lacerations from Marchette blades, glass, falls on sharp objects, working around moving mechanical equipment such as fans and automobile engines and falls where the hand is used in a reflex protective movement to resist the fall. Therefore, there was a strikingly similar characteristic to the flexor tendon injuries seen in civilian-type of injuries.

C. Principles of Management:

1. Clean laceration should be irrigated and debrided and if the cause is not a missile wound, it is permissible to loosely approximate the skin laceration. However, if grease, rice paddy dirt and foreign material contaminates the wound, it is better that this wound be debrided, dressed open using one layer of vasoline gauze to protect exposed tendons and closed in three days. No primary repair of tendon injuries is acceptable under these wartime conditions. Observation of these hand wounds in numbers will show that rarely does the wound heal and soften up to the degree where free tendon graft or secondary tendon repair would be permissible in less than four to five weeks. The ultimate success in tendon repair and free tendon graft requires absolutely ideal conditions in the wound of the hand and in the associated mobile joints. There is no justification for early primary repair of tendons or nerves in these hands. By contrast, total attention should be devoted to thorough debridement, extensive irrigation and assurance that the wound is clean and will heal without secondary reaction or delayed granulomatous healing.

2. The second responsibility of the physician here is proper dressing of a clean protected wound area followed by splinting with the wrist in 25° of dorsiflexion. This wrist position will produce a functional position in the hand. The thumb should be positioned in opposition which is the pinch position. This allows the pulp of the thumb to approximate the pulp of the long finger. Dressings should be moderate in size because large bulky dressings frequently prevent the fingers from lying in the position of pinch. Elevation of the hand above heart level for at least a week following one of these injuries will give the best assurance of rapid resolution of wound reaction and edema.

PERIPHERAL NERVE INJURIES

This section is a consensus opinion and recommendation of both the Orthopaedic and Neurological Groups.

A. General

1. The recommendations for nerve care are based on the well documented National Research Council sponsored study of peripheral nerve injuries produced by the Veterans' Administration following World War II and Korea. If a physician will devote the time to study these reports on 3600 peripheral nerve injuries from World War II, the recommendations

to follow will not appear arbitrary and restrictive but by contrast will appear as a sound and generally applicable approach to the care of the peripheral nerve injuries seen in war wounds. The peripheral nerve injuries seen within the war wounds are usually cared for by the general surgeon or orthopaedic surgeon because the available neurosurgeons are frequently fully occupied with care of head injuries and spinal cord injuries. The well documented cases in the peripheral nerve registry have been analyzed to such a degree and with such accuracy that certain statements will guide us in the management of these nerves at the time of wounding.

2. It is important to know the type of injury and the degree of injury to the peripheral nerve trunk as soon as feasible since these findings determine the early management. The interpretation of clinical examination studies, coupled with the description of the injured nerve, are important factors in the subsequent decision as to when and where and what type of surgery is indicated to rehabilitate the extremity. The first objective is early wound healing. Therefore, a wound should be thoroughly debrided and if an injury to the peripheral nerve is indicated by preoperative examination, then this injury should be described in the operative report when the nerve is seen. It will normally be found in the wound or adjacent to the wound, and if the wound is thoroughly debrided, the nerve will be found. The appearance of the nerve trunk should be described. If it is totally lacerated, this should be described and if partially lacerated, the estimate of the percentage of laceration should be recorded. A totally lacerated nerve, although it is not normally a retractile type of tissue, will retract and enlarge the nerve defect when motion of the adjacent joints occur. This passive retraction of the nerve therefore should be counteracted by anchoring this nerve at resting tension at normal anatomical rotation in the wound. This is accomplished with a small suture of silk rather than wire. The suture should pass through only the tip end and at the peripheral border of the nerve so that the epineurium is anchored to the adjacent fascia or muscle in the normal nerve bed. The nerve should not be debrided. The distal end of these nerves should likewise be anchored so that active rehabilitation motions in adjacent joints will not result in enlargement of the nerve defect by passive retraction. The wound should then be handled by dressings of fine mesh gauze, lightly placed fluff gauze, and an overlying stabilizing dressing. The wound should not be closed primarily but should be closed by delayed primary closure or split thickness skin graft in three to seven days in the hospital within the evacuation chain. Usually four to eight weeks minimum time for wound maturity and softening is required before consideration for nerve repair is reasonable. Nerve repair should never be done primarily in war wounds. Elective neurorrhaphies should be done only after thorough

clinical appraisal and evaluation by the usual clinical examination methods including all electrodiagnostic means available. A data flow sheet should be established and changes recorded by reevaluation at subsequent observation periods.

3. Primary repair of these nerves is not indicated and is to be avoided. There is always enthusiastic efforts at early nerve repair but long term results prove beyond question in dealing with the nerve in the war wound that claims for superior results are not borne out by later evaluation of recovery of nerve function. The patient should be evacuated to the hospital elected for definitive care. The injured extremity and nerve should be the immediate responsibility of the surgeon performing the peripheral nerve surgery. This means that reimmobilization of the extremity and the follow-up examination over extended periods of months is the responsibility of the surgeon who performs the elective neurorrhaphy. This cannot be accomplished in most hospitals in the overseas evacuation chain. Certain exceptions will always occur but they are unusual and should be individualized.

4. One offshore hospital handling approximately 38% of evacuees from Southeast Asia produced the following cases. In 9,000 patients there were 525 recognized peripheral nerve palsies. The great majority of these demonstrated early recovery during the few weeks of observation. Recovery was manifested by returning motor power, returning muscle tonus and beginning sensory recovery. Frequently this could be observed within the first 30 days of wounding. Fourteen percent of these palsies were in major mixed motor-sensory-nerve trunks. These were selectively abstracted for study. One hundred and fifty mixed peripheral nerve trunks were selected because they showed no sign of recovery or were known to be partially or completely lacerated at the time of wound surgery. The majority of these nerve injuries had been closed in Vietnam and the failure rate with secondary wound closure in Vietnam was 4.6% and failure in secondary closure for Japan was 3%. Seventy-four percent were closed or healed prior to admission. Fifty percent were caused by gunshot wounds and 50% were caused by multiple fragment wounds. Two Saturday night palsies were seen and two long thoracic nerve palsies were seen after carrying heavy shoulder loads.

B. Causalgia

1. In this group of 150 nerve injuries there were 39 disabling nerve pain syndromes. This represents 13% of the recognized peripheral injury. There were 11 cases of causalgia of the Weir-Mitchell type. This was 3.9%, approximately 1% higher than that observed in World War II.

These were all treated with sympathetic nerve blockade usually at least on three occasions. If nerve blockade produced relief of pain and increased vascularity in the extremity, the appropriate stellate or lumbar sympathetic ganglion resection was performed. Relief of pain was immediate and dramatic in 85% of peripheral nerve pain syndromes. Freedom from narcotic medication and active rehabilitative therapy could then proceed.

2. All patients had a diagnostic and/or therapeutic ganglion blockade using local anesthesia. This usually was performed on three occasions and if the block indicated the pain syndrome was interrupted, then the appropriate sympathectomy in the upper extremity was performed. One pain syndrome subsided after repeated stellate blockade; this was in ulnar nerve of the elbow. One tibial nerve syndrome subsided at seven days spontaneously. The other cases underwent sympathectomy with immediate relief in all but three cases, one of which had 75% relief and one of which had 25% relief.

3. There were 12 other spontaneous nerve pains but not of the Weir-Mitchell causalgia type. Ten of these underwent sympathectomy with immediate relief of pain permitting rehabilitation and ambulation. One patient responded to three successive stellate ganglion blockades. There were seven other cases of hyperesthesia or "over-response to touch." One required sympathectomy, one was evacuated still experiencing pain, one occurred following a chronic Pseudomonas infection and a draining gunshot wound, one responded to nerve section for a lesion of seven years duration. Others required sympathectomy to permit rehabilitation. The significant experience here is that disabling nerve pain syndromes can and should be managed in the offshore support hospitals successfully and earlier after injury before pain syndromes result in stiffened joints and psychologically depressed patients.

ADDITIONAL SUBJECTS

Acute Renal Failure (Japan Experience)

The treatment of 63 patients by dialysis over the past four years is described. Results are broken down into the initial 28 month period during which 43 patients required dialyses, 86% originating from SEA with a 48% survival rate and the last 20 month period consisting of 20 patients requiring dialyses, 55% originating from SEA with a 60% survival. Seven patients have been dialyzed peritoneally, distributed evenly over the entire period, primarily for "medical" causes of acute renal failure.

Breakdown into etiologic categories versus survival is as follows:

	Patients	% Mortality
Trauma	31	78
Malaria	11	36
Burns	7	86
Miscellaneous	14	7

Consideration of the early versus late experience shows a decrease of mortality from 86 to 55% in the traumatic group, 100 to 67% in the burns and 15 to 0% in the miscellaneous category. The current patient load in Japan appears stable at slightly over 1 patient per month as compared to RVN which currently averages 3-5 patients per month requiring dialysis. The number of patients conceivably salvageable by dialyses but referred "too late" has decreased from 7 in the first two years to zero in the last two years.

Of the last 21 patients dialyzed, the serum bilirubin was elevated in 13 of whom 5 had readily explainable causes as determined from associated clinical findings. Serum transaminases and alkaline phosphatases reflected diverse but usually abnormal values in the remainder. Depression of the prothrombin time was more frequent and marked than expected. Patients are being routinely investigated in search of a common denominator although at present it appears there are multiple etiologies.

Army Medical Research in Vietnam

Studies carried out during the past year by the Trauma Study Section of the US Army Medical Research Team (WRAIR) Vietnam have been largely of a descriptive nature. Investigation has shown that troops in Vietnam are generally somewhat dehydrated prior to injury and that resuscitation efforts should take this into account. Most patients who had been hypotensive and

were treated at one of the surgical hospitals were found to have a persistent decrease in the red cell mass in the postoperative period lasting over several days. This red cell mass decrease may be accentuated at the time of edema resorption and therefore be temporally related to maximum postoperative blood volume. Blood volume changes following traumatic blood loss are associated with a proportional decrease in extracellular fluid.

Many patients with traumatic injuries were found to have hypoxemia, frequently of unexpected severity. A normal or elevated pH (respiratory alkalosis) was a common finding. Acidosis was seen in those patients who were hypotensive for a prolonged period of time.

Clotting studies have shown intraoperative and early postoperative depression of several factors which are best correlated with administration of "banked" blood. Subsequent changes are in a direction of repletion with daily fluctuations during the first several postoperative days.

Use of the cyanoacrylate "tissue glue" has continued in selected cases. In most instances it has been applied to the liver or kidney but it has been useful in some large soft tissue wounds in which uncontrollable oozing was encountered.

It would seem that investigative effort within Vietnam would be most advantageously directed toward surgical problems which exist within the theatre. Pulmonary insufficiency, sepsis, and upper GI bleeding comprise the three most common causes of death in the later (beyond 5 days) post-op period. These then would seem to be the most fruitful areas for study.

Pulmonary function is being investigated at our unit in seriously injured patients. In two patients with lung contusion studied recently, both were found to have significant (20-44%) physiologic shunts while breathing 100% oxygen. In both patients these "shunts" essentially disappeared with ventilatory assistance.

Such pulmonary changes are being correlated with alterations in cardiac output, blood volume and ECF volume. Studies to delineate pulmonary changes associated with systemic sepsis, to describe gastric acid secretion, and to correlate the response of an administered fluid load with "fullness" of the vascular tree and "transcapillary" movement of fluid in patients with systemic sepsis are projected for the near future.