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Non-operative approach to blunt trauma in childhood *

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Summary

The background, rationale and limitations of the non-operative approach to blunt trauma in childhood are presented. The indications for open surgical intervention for abdominal, thoracic and vascular injuries are outlined. The determinants governing the plan of management in blunt trauma are discussed.

Key words: Trauma in children, abdominal injury, thoracic injury, vascular injury

Introduction

In the present era, the majority of injuries in children are of the non-penetrating variety. This observation does not hold true in countries with military unrest. The following communication addresses itself to the non-operative approach to blunt trauma in children. This approach has become clinically applicable during the past two decades since the Toronto Group of workers at the Hospital for Sick Children reported in 1968 their encouraging results on preservation of the traumatized spleen. The concept of conservative surgical management has been strengthened by the advent of imaging techniques that have supported the efficacy and safety of this approach.

Physiological background

Adoption of this modality of management requires an understanding of the physiological set up of the pediatric patient. The estimated blood volume of a child is calculated as 80 cc. per KBW. The primary response to blood loss is a tachycardia and an increase in peripheral vascular resistance. When this loss exceeds 25 % of the blood volume and is not replaced, hypotension sets in. In addition to blood pressure measurement, the adequacy of circulation may be assessed by pulse amplitude, color and temperature of the extremities, capillary refill, mental alertness, and urine output. In the absence of a known body weight, the following formula may be used: estimated weight (kg) = (2 X age in years) + 8.

Oxygen delivery to the tissues is a function of cardiac output, hemoglobin concentration, and oxygen saturation as indicated by the following formula:

O2 delivery (ml/min/M2)= cardiac index X arterial O2 content X 10 = 520 ml. to 720 ml.

Normal oxygen consumption is reported to be 130-160 ml/min/M2. Hence, the ratio of O2 delivery to -O2 consumption is 3:1 or 4:1.

In healthy individuals, the cardiac output is noted to increase significantly when the hemoglobin level drops to 7 gm/dl. Experimentally, survival has been reported with more severe acute isovolemic anemia (hemoglobin level as low as 4 gm/dl), provided the subject is anesthetized and the respiration is controlled by a ventilator.

Initial management of the trauma victim

A general assessment of the trauma victim is essential initially to determine the extent and severity of the injury and the type of response to trau-

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ma. The six determinants included in the Pediatric Trauma Score which was advanced by the American College of Surgeons and the American Pediatric Surgical Association include: the size of patients (kg), ability of the patient to keep the airway patent, the level of systolic blood pressure (B.P.) the status of central nervous system (CNS), the presence or absence of open wounds and of skeletal fractures. In the absence of a properly sized BP cuff, the circulation may be assessed by the palpability of a pulse at the wrist or the groin levels. This trauma score helps in triaging the patients and in evaluating the effects of therapy.

The initial supportive treatment that is offered to the trauma victim is almost similar in patients with blunt and penetrating injuries. Vascular access in children may pose a problem as compared to adults. In the young subject, a venesection is recommended. In older children and adolescents, percutaneous catheterization of the internal jugular or subclavian vein is feasible and safe.

The use of computarized tomography (C.T.) scan with double contrast (I.V. and oral) has led to an early detection of abdominal injuries and is recommended for use in the hemodynamically stable patient with blunt abdominal trauma. CT scan is helpful in assessing the perfusion of organs, and extent of the injury. When compared to nuclear liver-spleen scan, CT scan is more informative and indicative of injuries to other viscera. CT scan is more specific than ultrasonography in the initial assessment. On the other hand, ultrasonography is useful in determining serially the progress of healing of the injury and in guiding percutaneous drainage of an intra-abdominal or subprenic collections. In the absence of CT scan facilities, and/or in the presence of hemodynamic instability, abdominal paracentesis or preferably peritoneal lavage may help in elucidating equivocal abdominal clinical findings, since the usefulness of plain radiography is limited.

For patients with moderate CNS injury (Glascow coma score (GCS)=9), a CT scan of the head is advised in the hemodynamically stable patients, who would also require hyperventilation to achieve a $PaCO_2$ of 25-30 mmHg in order to control cerebral edema.

The initial management of hypovolemia due to blood loss consists of the rapid administration of Ringer's lactate in a dose of 20 ml/kg. This may be repeated if the patient's circulatory status remains unstable. Packed cell transfusion is indicated if crystalloids fail to resuscitate and/or the blood resuscitation are to ensure isovolemia, hemoglobin values of 8 gm/dl, adequate oxygen delivery and a urine output of at least 1 ml/kg/hr. If I.V. fluids fail to resuscitate,the following conditions must be ruled out: persistent internal bleeding, cardiac complications (tamponade or failure) and/or missed intestinal perforation.

Clinical Meterial

1.Abdomen and Pelvis

In blunt trauma to the abdomen, the spleen is the most frequently involved organ, then the liver, kidneys and intestines. Post-traumatic asplenia has been associated with an increased incidence of sepsis, leading frequently to an early death, especially in the young subject. This fatal outcome has been explained on the basis of immunological defects developing after splenectomy. In the absence of associated G.I. injuries, patients with splenic injuries, whose hemodynamic stability is ensured by I.V. fluids, continue to do well without operation, as proven clinically and radiologically by early and long-term follow-up. About 10 % of these patients require an emergency laparatomy to control blood loss that exceeds 50 % of the blood volume.

The same plan of treatment is applicable to patients with liver lacerations whose injury had not resulted in an avulsion of the liver parenchyma or was not complicated by an infection. Renal injuries that are not involving the hilum or the renal artery may also be treated successfully with I.V. hydration, bed rest and antibiotics. A cystic collection in the left upper quadrant of abdomen following blunt trauma usually represents a sequela of a pancreatic injury that had failed to resolve on total parenteral nutrition (TPN) and nothing by mouth (N.P.O.). The pseudocyst may be confirmed by ultrasonography and may be amenable to percutaneous drainage under guidance of the ultrasonographer.

Duodenal hematoma, as verified by G.I. series or ultrasonography often responds favorably to non-operative measures consisting of nasograstric suction and TPN for 10-14 days.

Pelvic fractures resulting in a urethral tear would require initially a cystostomy and at a later date repair of the urethra. Massive bleeding complicating a pelvic fracture is best controlled by the angiographer in the X-ray Department using the embolization technique. Rupture of the urinary bladder is best demonstrated by cystography. In this type of injury, CT scan with contrast is unreliable. If perforation of the bladder is extraperitoneal it can be treated successfully by keeping the bladder decompressed using a transurethral catheter.

Chylous ascites after blunt trauma is a rare coındition. We had lately the opportunity to treat successfully a battered infant with this condition by using a 5-week regimen of N.P.O., T.P.N., and intermittent percutaneous needle dainage of the peritoneal cavity.

In summary, an exploration celiotomy in blunt abdominal trauma is indicated under the following conditions:

1. G.I. perforation.
2. Continued bleeding and/or infection from a solid organ.
3. Unresolving pancreatic pseudocysts.
4. Aortic or arterial injuries.
5. Major renal extravasation.
6. Intraperitoneal rupture of urinary bladder.
7. Pelvic fracture with deep perineal laceration requiring a colostomy.
8. Avulsion of glandular ducts (e.g. biliary, pancreatic).
9. Rupture of the diaphragm.

2. Thorax

Pleural accumulation of air and/or fluid may complicate an injury to the thoracic cage and/or pulmonary contusion. Besides, pleural effusion may set in secondary to a subphrenic organ injury, like the splen, kidney or liver. When present in a significant quantity and associated with fever, its decompression with an intrapleural catheter connected to a closed system of drainage becomes indicated.

Cardiac contusion, as ushered by arrhythmia and heart failure, is rare. Its diagnosis is confirmed by chemical studies (elevated C.P.K.)-MB enzyme values), 2-D echocardiagraphy and electrocardiagraphy. The treatment is supportive, requires hemodynamic monitoring and the use of vasoactive agents. Severe blunt trauma to the heart is usually fatal due to rupture of the free cardiac wall, ventricular septum or an intracardiac valve.

Flail chest may be noted after blunt trauma when 4 or more ribs are fractured at two points or when the rib fractures are associated with a sternal fracture. The chest wall instability interferes with proper ventilation and with handling of the tracheobronchial secretions. endotracheal intubation and controlled ventilatory support for 7-10 days have been beneficial in the menagement of the complicating respiratory insufficiency.

The non-operative approach is usually successful in blunt trauma to the chest, but has to be substituted by an open thoracotomy under the following conditions:

1. When the blood loss through the chest tube is greater than 2 cc./kg/min., or when it amounts to about 50 % of the blood volume in two hours or less.
2. When there is evidence of an aortic tear by aortography.
3. In the presence of a persistent massive air leak due to a bronchial laceration.
4. When an early esophageal perforation is evident.
5. In case of cardiac arrest when a closed cardiac massage fails to produce an adequate cardiac output after 10 minutes of massage, or when there is an associated chest wall instability.

3. Arterial injuries

Post-traumatic peripheral arterial insufficiency may be secondary either to vascular spasm or to thrombosis localized to the site of injury. Con-

tinued bleeding from a peripheral vessel after blunt trauma is rare and suggests the presence of a coagulopathy, or an intrinsic defect in the arterial wall. When associated with a displaced fracture, the arterial insufficiency commonly improves after reduction of the fracture. If the peripheral blood flow remains diminished for 4-6 hours, as indicated by capillary refill, by doppler and by the development of paresthesia or anesthesia in the affected limb, then arteriography or Doppler flow imaging followed by surgical exploration become necessary. In selected cases, e.g. neonates, when bleeding is not a consideration, and the results of arterial reconstruction are not promising, the use of fibrinolytic agents (eg. urokinase) and anticoagulants (eg. heparin) has been encouraging and has led to dissolution of the occlusive thrombus and restoration of adequate perfusion to the extremity.

The indications for emergency surgery in arterial injuries may be outlined as follows:

1. Presence of continued bleeding from an injured vessel which is not on basis of coagulopathy.
2. Absence of peripheral blood flow by a doppler or capillary refill for 3 hours or more.
3. Continued reduction of peripheral blood flow for 6 hours after the injury, especially when associated with a neurologic deficit.

Conclusions

The following determinants govern the plan of management of the trauma victim:

1. Location and severity of injury

A. Continued occult bleeding exceeding 50 % of the blood volume mandates an open intervention or embolization of the bleeding vessel (s).
B. Adequacy of perfusion of an injured organ that cannot be ensured by supportive measures will have to be attended to without delay by reconstructive operative procedures or amputations of the devascularized part.
C. Leakage into a body cavity of secretions from the G.I. tract, biliary tree or urinary bladder is a sine qua non of an exploratory celiotomy.
D. Multiplicity of system injury: A patient with splenic and other organ injuries may not be a candidate to receive the same treatment as another patient with an equivalent isolated injury of the spleen.

2. Trauma victim

A. Body size: It is essential that the pediatric victim be exposed to vigilant care by pediatric specialist and to an environment that is conducive to a smooth convalescence.
B. Coagulation profile: Non-surgical causes of occult bleeding must be ruled out before a decision on an operative intervention is made.
C. Religious faith of the victim: In case of Jehova's witnesses, the plan of management may be tailored according to their faith which condemns the use of homologous blood.
D. Hemodynamic stability: The extent of investigation in the x-ray department and the rapidity with which the victim is transferred to the O.R. depend on his/her hemodynamic status on admission to the hospital.

3. Efficacy of the available therapeutic measures

The non-operative and conservative approach to blunt trauma has continued to be successful in the majority of children so long as the operator recognizes its limitations and possible risks. The long-term follow-up of patients undergoing this mode of therapy confirms nature's ability and potential to heal traumatized organs so long as the appropriate supportive measures are provided.

4. Referral trauma medical center

The patient with major trauma affecting one or more organs/systems is best managed in a center that is equipped with the necessary diagnostic radiologic and laboratory facilities and their supporting personnel, as well as the nursing, operating and rehabilitation units with their ancillary monitoring equipment, in addition to the different medical specialists that may be needed on an emergency basis to attend to the pediatric trauma patient. It is important that the regional health care system be designed for the application of a safe and equitable triaging of trauma cases among the various local medical centers. The pediatric surgeon trained in trauma remains the best candidate for leadership of the trauma team.