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Original Research Article

Spleenic Injury Management at a Tertiary Care Center in Rural Area of India - A Clinical Analysis

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ABSTRACT

Introduction: Trauma today is the biggest killer in young age group. It kills with a cold face, sees no one young or old, man or woman, adult or child. Every eight and a half minute sees a life lost due to an accident and every minute one accident in India. Spleen is the commonest intra-abdominal organ that is injured after blunt abdominal trauma.

Method: The study includes 30 patients with splenic injury, admitted for blunt abdominal trauma, in a major tertiary institution in rural area of India for trauma in between 2005 to 2009. They were studied with respect to incidence, modes of clinical presentation, management and outcome.

Results: Maximum patients were reported between 21 to 30 years. Males are predominantly affected. 84% of patients presented in casualty within 6 hours of injury. Maximum 67% of patients having splenic injury are due to vehicular accidents. 15 patients underwent splenectomy mainly due to the grade of injury and a few due to haemodynamic instability. 10% patients expired, mainly due to head injury and associated fracture of long bones, one patient expired due to post-operative malarial infection. None of the patient died due to non-operative management. Only 3 patients (10%) were having isolated spleenic injuries neither associated intra-abdominal injury nor associated non abdominal injuries.

Conclusion: With better understanding of the role of spleen in body immunology, the management of splenic trauma has changed in last two decades and today splenic salvage is the goal. Laparoscopy for abdominal trauma carries a high diagnostic yield in the identification of visceral injuries.

Key words: Spleenic Injury, Management, Trauma.

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INTRODUCTION

Trauma today is the biggest killer in young age group. It kills with a cold face, sees no one young or old, man or woman, adult or child. Every eight and a half minute sees a life lost due to an accident and every minute one accident in India. Meticulous examination, continuous monitoring and high degree of suspicion forms the basic pillars of blunt abdominal trauma management.

Spleen is the commonest intra-abdominal organ that is injured after blunt abdominal trauma. A team effort of trauma surgeons and radiology experts help an early diagnosis and treatment which facilitated primary management of these injuries. Injuries to the spleen may be treated either by operative or non-operative technique. Newer operative techniques, modern anesthesia, and blood transfusion facilities have made splenic injury management conservative, after recognition of its immunological importance. With standard diagnostic methods for assessment of splenic injury such as peritoneal lavage, CT and USG and with the advent of diagnostic laparoscopy, grading of splenic injuries may be done. It appears to be safe in the paediatric age group to deal with mild splenic lesions by conservative management, in stable patients, in view of its immunological importance.

METHOD

Aim of Study was: To know the incidence of splenic trauma, modes of presentation and grade them, To identify the mechanism of the injury and To study the co-relation between the severity of splenic injury to the line of management.

The study includes 30 patients with splenic injury, admitted for blunt abdominal trauma, in a major tertiary institution in rural area of India for trauma in between 2005 to 2009. They were studied with respect to Age & sex, Mode of sustaining injury, Time interval between injury, to admission and management, Condition on admission, Signs & symptoms, Resuscitative measures, Investigations, Different methods management, Indications for Laparotomy, findings and procedures done, Types and grades of splenic injury, Units of blood required in management, Associated injuries, Postoperative course and hospital stay, Morbidity and mortality. All the patients of abdominal injury were first assessed in casualty by surgical resident and after evaluation, accordingly admitted to intensive care unit. Once the patients were admitted, a primary survey (life sustaining priorities) carried out: Airway – to secure a patent airway and optimise ventilation, Breathing,

Circulation – establish IV access to combat hypotension and to enhance cardiovascular performance, Immobilise cervical spine, Blood sent for grouping, cross-matching and haematocrit. Once the patient's general condition was stabilized, secondary survey was conducted. This consisted of thorough physical examination including : Examination of chest, Examination of abdomen, flanks, back, perineum and axillae, Examination of head, spine and neck, Peripheral pulses, neurological examination, Per rectal examination for blood and sphincter tone, Splinting of long bone fractures. Wherever deemed necessary, specialists from appropriate fields were called for. Once stable, tertiary survey was carried out to rule out occult injuries – such as bowel perforations or pancreatic injuries.

Whenever a splenic trauma was suspected, the following therapeutic measures were carried out - Nil by mouth, RT aspiration 1 hourly and continuous, Foley's catheter to monitor urine output and to rule out haematuria, Intravenous fluids, both crystalloids and colloids were administered through wide bore IV canula in the upper extremity, Blood transfusion given depending on Hb and PCV, Broad spectrum antibiotics (Cefotaxime/Gentamycin/Metronidazole) given. Inj. Tetanus Toxoid 0.5 cc IM given. Inj. Ranitidine (50 mg) IV given to prevent stress induced gastritis. Simultaneously, the following investigations were carried out – Hb and PCV, Blood grouping and cross –matching, BUN, Serum Creatinine and random blood sugar, Urine examination, X-ray chest and abdomen, abdominal paracentesis, USG and CT scan (abdomen).

On coeliotomy, the following points were noted – Grade of splenic injury, type of procedure performed, other associated visceral injuries. Postoperatively, the patients were given IV fluids and kept continuous Ryle's tube (RT) aspiration. The quantity of fluid and electrolyte administration were adjusted according to chemical parameters i.e. temp, pulse, BP, CVP, urine output, RT aspirate and serum Na+ and K+ levels. All patients were given broad spectrum antibiotics from the start. Higher antibiotics were added according to the patient's postoperative course and Inj.Pneumovac given.

The patients were kept on continuous RT aspiration till – Decreasing nasogastric aspirate, decreasing abdominal distension, return of bowel sounds and passage of flatus or stools. Early ambulation and physiotherapy were encouraged to prevent deep vein thrombosis and for chest complications – Tincture benzoin inhalations, Deep breathing exercises, frequent change of position and early ambulation were done. Adequate hydration was maintained.

RESULTS

The study includes 30 cases admitted in our hospital. Maximum patients (12) were reported between 21 to 30 years. Males are predominantly affected. 90% Males (27 patients) and 10% Females (3 patients). The time interval between the injury and presentation or admission is shown in the above table. Maximum i.e 84% (25 patients) of patients presented in casualty within 6 hours of injury. The time interval between injury and patient taken for surgery. Maximum 89% (16 out of 18 patients) of patients were taken for surgery within 6 hours of injury. Maximum 67% of patients having splenic injury are due to vehicular accidents. 90% patients had abdominal signs. 5% patients had abdominal signs negative due to altered sensorium, head injury being the key factor. 12 patients (40%) were managed conservatively. 15 patients (50%) underwent splenectomy mainly due to the grade of injury and a few due to haemodynamic instability. 3 patients (10%) underwent splenorrhaphy. 30% patients required less than 2 units of blood, 60% patients required 2 to 4 units of blood and 10% patients required more than 4 units of blood. Blood requirement was more influenced by associated injury and grades of injury rather than by process of conservation. 10% patients expired, mainly due to head injury and associated fracture of long bones, one patient expired due to post-operative malarial infection. None of the patient died due to non-operative management. About 22% patients were associated liver injuries & 17% patients were associated retroperitoneal injury. Head injuries constituted 50% (15 patients). 40% patients had other bony fractures, 20% patients had fracture ribs on left side & 7% patients had associated pelvic fracture. Only 3 patients (10%) were having isolated spleenic injuries neither associated intra-abdominal injury nor associated non abdominal injuries.

Table 1: Age Incidence

AGE (in years)	NO. OF PATIENTS	PERCENTAGE
0 – 10	1	3.33
11 – 20	5	16.67
21 – 30	12	40.00
31 – 40	8	26.67
41 – 50	3	10.00
> 50	1	3.33

Table 2: Sex Incidence

SEX	NO. OF PATIENTS	PERCENTAGE
MALE	27	90.00
FEMALE	3	10.00

Table 3: Time of Presentation

TIME INTERVAL (in hours)	NO. OF PATIENTS	PERCENTAGE
< 2	6	20
2 – 4	11	36.67
4 – 6	8	26.67
6 – 8	4	13.33
8 – 10	1	3.33
> 10	0	0.00

Table 4: Lapse Time of Injury & Surgery

TIME INTERVAL (in hours)	NO. OF PATIENTS	PERCENTAGE
< 2	2	11.11
2 – 4	8	44.44
4 – 6	6	33.34
6 – 8	2	11.11
> 8	0	0.00

Table 5: Mode of Injury

MODE OF INJURY	NO. OF PATIENTS	PERCENTAGE
VEHICULAR ACCIDENT	20	66.67
FALL FROM HEIGHT	7	23.33
ASSAULT	3	10.00
OTHERS	0	0.00

Table 6: Clinical Presentation

ABDOMINAL SIGNS	NO. OF PATIENTS	PERCENTAGE
POSITIVE	27	90.00
NEGATIVE	3	10.00

Table 7: Grades of Splenic Injury

GRADES OF SPLENIC INJURY		NO. OF PATIENTS	PERCENTAGE
I	CAPSULAR TEAR OF MINOR PARENCHYMAL LACERATION (< 10%) SURFACE AREA	12	40.00
II	MINOR CAPSULAR AVULSION (10 – 50%) WITH ACTIVE BLEED	4	13.33
III	EXPANDING SUBCAPSULAR HAEMATOMA (> 50 %) WITH INTRA PARENCHYMAL HAEMATOMA	8	26.67
IV	RUPTURED PARENCHYMAL HAEMATOMA WITH ACTIVE BLEED	4	13.33
V	SHATTERED OR AVULSED SPLEEN	2	6.67

Table 8: Type of Management

PROCEDURE	NO. OF PATIENTS	PERCENTAGE
CONSERVATIVE	12	40.00
SPLENORRHAPHY	3	10.00
SPLENECTOMY	15	50.00

Table 9: Number Of Units Of Blood Transfusion

NO. OF UNITS	NO. OF PATIENTS	PERCENTAGE
0	1	3.33
1	8	26.67
2	6	20.00
3	5	16.67
4	7	23.33
5	3	10.00
> 5	0	0.00

Table 10: Mortality

TOTAL NO. OF PATIENTS	NO. OF PATEINTS EXPIRED	PERCENTAGE
30	3	10.00

Table 11: Associated Injuries

(A) ASSOCIATED INTRA- ABDOMINAL INJURY

INTRA ABDOMINAL INJURY	NO. OF PATIENTS	PERCENTAGE
ISOLATED SPLENIC INJURY	25	83.33
ASSOCIATED INTRA ABDOMINAL INJURY	5	16.67

(B) SPECIFIC ORGAN INJURY

SPECIFIC ORGAN INJURY	NO. OF PATIENTS	PERCENTAGE
LIVER	4	22.22
STOMACH & DUODENUM	1	5.55
BOWEL & MESENTRY	1	5.55
RETEROPERITONEUM	3	16.66

(C) NON ABDOMINAL INJURY

NON ABDOMINAL INJURY	NO. OF PATIENTS	PERCENTAGE
FRACTURE RIBS	6	20.00
FRACTURE PELVIS	2	6.67
HEAD INJURIES	15	50.00
OTHER BONY FRACTURES	12	40.00

DISCUSSION

Etymologists say that the word "abdomen" is derived from the Latin "abdere" meaning 'to hide" and indeed in blunt abdominal trauma, the consequences of the forces delivered to the torso are often hidden for a time and a very high index of suspicion is mandatory to avoid diagnostic errors. The spleen was regarded by Galen as "an organ of mystery" Spleen can be ruptured by violence leaving no visible mark on the abdomen and there are innumerable historical accounts of the effects of warfare on the abdominal viscera.

Aristotle, the Greek philosopher may be credited with being the first to record visceral injuries in the case of blunt abdominal trauma. The first case of ruptured spleen was reported by Celsus in the 15th century. First recorded splenectomy was by Adrian Zaccarelli in 1549 in Naples. First recorded partial splenectomy was by Viard in 1590. Zikoff (1895) reported the first case of suture of a lacerated spleen. Morris and Bullock, after conducting series of experiments concluded that removal of the spleen "robs the body of its resistance". Leo Dretzka (1930) established the principles for successful splenorrhaphy. First case report suggesting delayed rupture of spleen following injury was that of Conway Evans in 1866. King and Shumacker in 1952, reported overwhelming post splenectomy infection (OPSI). In 1962, Christo reported 8 partial splenectomies which renewed interest in spolenorrhaphy. In 1981, Shackford reported use of system to grade injuries to spleen. Successful non-operative management of blunt splenic injury in paediatric age group was first proposed three decades back by Upadhyaya.

EMBRYOLOGY

Embryologically, development of spleen begins in 5th week of gestation. It develops by mesenchymal differentiation along the left side of dorsal mesogastrium in 8 mm embryo between stomach and pancreas. Mesenchymal remnants that do not fuse with main splenic mass account for high incidence (15-30%) of accessory spleens in adjacent tissues. These accessory organs are present in decreasing order of frequency in the hilus of spleen, the gastrosplenic ligament and splenocolic ligament, splenorenal ligament and greater omentum. They may also be found in pelvis of female, either in presacral region or adjacent to left ovary or in the scrotum in juxtaposition to left testicle. They can serve the function of spleen following splenectomy and may present complications such as "overwhelming post splenectomy sepsis".

ANATOMY[17-19,29,30,39]

Spleen is the second largest organ of reticuloendothelial system. It is a wedge shaped organ lying mainly in left hypochondrium and partly epigastrium. It is soft, high vascular and dark purple in colour. On average, spleen is 1 inch thick, 3 inches broad, 5 inches long, 7 ounces in weight and is related to 9th to 11th ribs with long axis parallel to 10th rib and normally it is not palpable. It has a cumulative blood flow of about 300 ml/minute.

It has following impressions where different organs come in contact with spleen (Fig -1):

(a) Gastric impression for fundus of stomach between superior and intermediate border.

(b) Renal impression for left kidney between intermediate and inferior border.
(c) Colonic impression: for splenic flexure of colon which occupies triangular area adjoining the anterior end of spleen.
(d) Pancreatic impression for tail of pancreas between hilum and colic impression.
(e) Hilum which is situate between inferomedial part of the gastric impression.
It's position within the abdomen and its relations to other structures are maintained by suspensory ligaments which are:
1. Gastrosplenic ligament: From hilum of spleen to the greater curvature of stomach containing short gastric vessels, associated lymphatic and sympathetic nerve.
2. Lienorenal ligament: From hilum of spleen of anterior surface of left kidney containing tail of pancreas, splenic vessels and associated lymph nodes, lymphatic and sympathetic nerves.
3. Phrenicocolic ligament: From splenic flexure of colon to the diaphragm opposite 11th rib in midaxillary line.

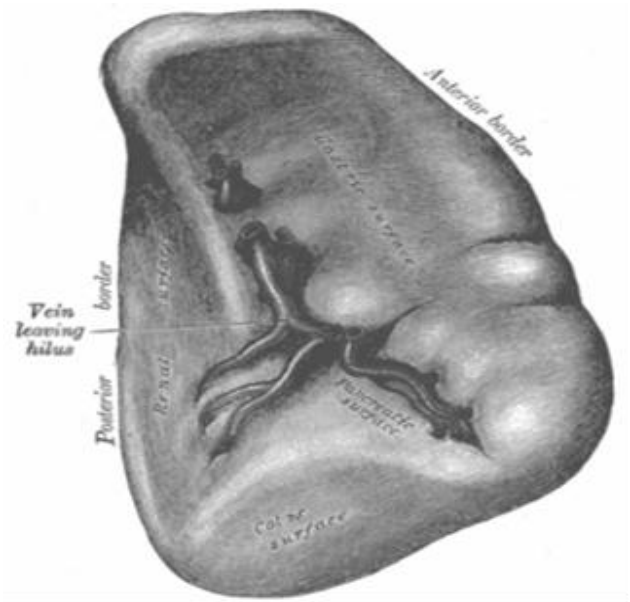

Fig 1: Showing Anatomy of Spleen

Arterial Supply
It is supplied by splenic artery, which is the largest branch of celiac trunk. Artery is tortuous in its course, to allow for movements of spleen. It passes through lienorenal ligament to reach hilum of the spleen where it divides into 5 or more branches. On basis of its blood supply, spleen is said to have superior and inferior vascular segments and these two segments are separated by avascular plane. Because of such vascular architecture, partial resection of spleen is possible.

Venous Drainage
It is mainly through splenic vein, which is formed at hilum of spleen and runs a straight course behind the pancreas. It joins the superior mesenteric vein behind the neck of pancreas to form portal vein.

Lymphatic Drainage
Splenic tissue proper has no lymphatics.

Nerve Supply
Sympathetic fibers are derived from coeliac trunk and are vasomotor in nature. It also supplies to the smooth muscle of the capsule.

Physiological Functions of Spleen
The spleen is not essential to life. The role of spleen in health and disease has not been fully elucidated, and it was correctly referred to as "organum plenum mesterium" in Latin by Galen meaning organ full of mystery.
However, spleen is known to have the following functions:
1. Haemopoiesis
During early fetal development, the spleen produces red and white blood cells. By 5th month of gestation, the spleen and other extramedullary sites of blood cell production no longer have haemopoietic function but retain the capability throughout life.
2. Platelet Reservoir
The spleen normally sequesters 30-40% of blood platelets. The life span of platelets in circulation is therefore about 10 days. Platelet phagocytosis is normal function of spleen but in conditions like idiopathic thrombocytopenic purpura, it is accelerated.
3. Destruction of Red Blood Cells
Abnormal and rigid red cells are destroyed in red pulp by process of culling and pitting. Culling refers to the filtering and phagocytosis of old red blood cells which have either been damaged or contain inclusions such as nuclei, nuclear remnants (Howell-Jolly bodies), target cells, siderocytes and spherocytes. Pitting is removal of certain inclusions e.g. red blood cell nuclei or malarial parasites from red blood cells without destroying the cells.
4. Response to Antigenic challenge
There is proliferation of T-lymphocytes within the lymphatic sheaths, and antibody forming B-lymphocytes within lymphatic nodules of spleen. This results in increased production of humoral immune factors of both B and T cell origin : antibody (especially IgM), tuftsin (a peptide which stimulates phagocytosis by neutrophils), opsonins (which are antibodies and other proteins which reacts with bacteria and fungi to make them more susceptible to phagocytosis), properdin (and immunoglobulin found in unchallenged animals which have not formed antibody, that fixes complement to bacterial and fungal surface polysaccharides before phagocytosis), and interferon (a glycoprotein which exerts an antiviral effect by stimulating killer cell macrophage activity). Splenectomised patients develop decreased levels of all these factors and this reduces resistance, in particular to encapsulated bacteria.
5. Phagocytosis of Foreign Substances
This is done by reticuloendothelial macrophages with in spleen. Particulate matter, bacteria, fungi and protozoa are removed from circulation by these macrophages.

MECHANISM OF SPLENIC INJURY[17]

The spleen is the most common intra- abdominal organ injured in blunt abdominal trauma and is frequently injured in penetrating abdominal injury. Mortality rates from splenic injuries ranges between 10 – 20% depending upon associated injuries.
Splenic injuries can occur due to:
1. Blunt trauma
2. Penetrating trauma
3. Iatrogenic trauma
(1) Blunt Trauma: Blunt injuries are thought to result from a combination of crushing, deforming, stretching and shearing forces. The magnitude of these forces is directly related to the mass of the object involved, the rate of their acceleration or deceleration and their relative direction on impact. Injury results

when the sum of these exceeds the cohesive strength of spleen and injuries produced are a constellation of contusions, abrasions, fractures and rupture of organ. Blunt injuries usually represents energy transferred to underlying visceral and vascular structures in the anatomical region sustaining direct impact which is left hypochondrium and lower left chest in case of spleen. Hence, high incidence of splenic trauma is noticed with left side lower rib fractures.

(2) Penetrating Trauma: Penetrating injuries could be from sharp, long penetrating instrument or by fire- arms. Injuries from fire-arms are related to ballistics of weapon, the trajectory of the missile and the tissues or organs involved. The wounding potential of the weapon is determined by its kinetic energy.

KE = ½ mass x velocity^2. Based on this formula, the weapons may be classified as:

Low velocity < 1000 ft/sec e.g., knife

Medium velocity 1000 to 2000 ft/sec

High velocity > 2000 ft/sec e.g., bullets.

Low velocity weapons are thought to produce injury by direct crush and tearing mechanisms and high velocity weapons induce tissue cavitation. Thus, spleen may be injured in abdominal or thoracic or abdomino-thoracic injuries.

(3) Iatrogenic Trauma: These are produced due to surgical intervention which might require splenectomy. Injuries to the spleen are possible in operative procedures on the stomach, esophageal hiatus, vagus nerves, pancreas, left kidney and adrenal gland, transvers and descending colon and splenoportography. Special precautions must be taken to prevent this e.g. normal coagulation profile before doing splenoportography, placing of mops behind the spleen in surgery of stomach, esophageal hiatus and to avoid excess traction near the splenic pedicle.

GRADING OF SPLENIC INJURY[31]

Proposed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma.

GRADE *		INJURY DESCRIPTION
	-	Nonexpanding subcapsular haematoma (< 10% surface area)
GRADE – I	-	Superficial non-bleeding laceration (< 1cm deep parenchymal involvement)
	-	Large nonexpanding subcasular haematoma (< 10-50% of surface)
GRADE – II	-	Actively bleeding capsular tear or parenchymal laceration (1-3 cm deep) without trabecular vessel involvement
	-	Expanding or ruptured subcapsular haematoma (> 50% surface area)
GRADE – III	-	Deep laceration not devascularising (> 3 cm deep) any portion of spleen
	-	Intraparenchymal haematoma (> 2 cms in diameter)
	-	Ruptured intraparenchymal haematoma with active bleeding
GRADE – IV	-	Bisection or hilar injury producing major (> 25% splenic volume) devascularisation
	-	Shattered or avulsed spleen
GRADE – V	-	Severe hilar laceration which devascularises entire spleen

*Advance one grade for multiple injuries up to Grade-III

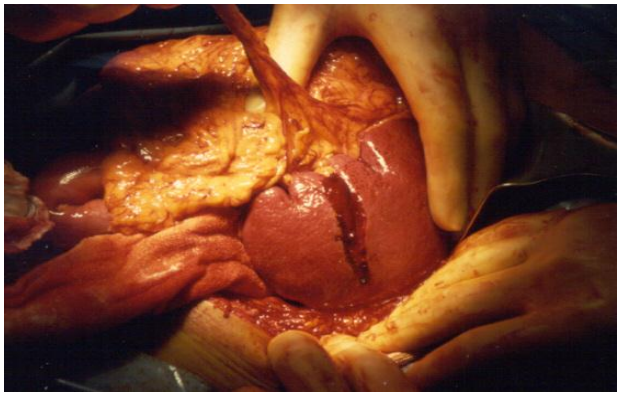

Fig 2: Showing Grade – II Spleenic Injury

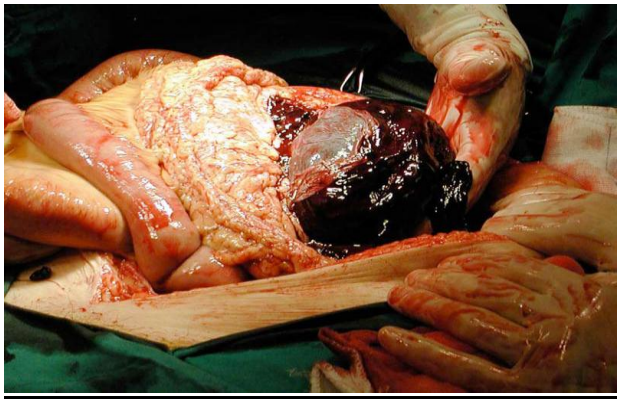

Fig 3: Showing Shattered Spleen

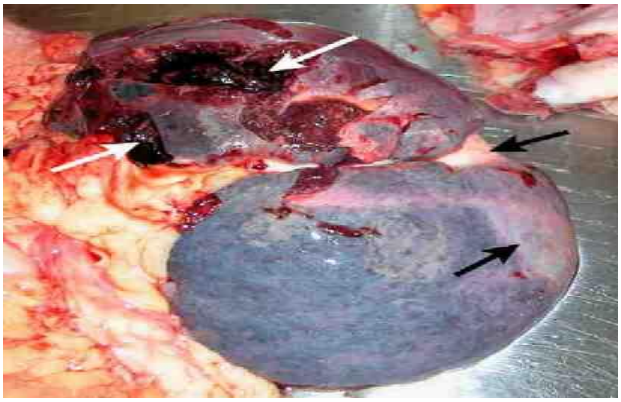

Fig 4: Traumatic Ruptured Spleen

DIAGNOSIS

Splenic trauma is one of the most common organ injury following blunt abdominal trauma and particularly if there has been direct injury to the left upper quadrant of the abdomen from any angle. Occasionally, a fall without direct trauma to the trunk can rupture the spleen, especially if it is diseased or enlarged (e.g., in infectious mononucleosis or malaria.)

A Splenic injury should be suspected in cases having left side lower rib fractures or friction abrasion/bruise over left lower chest without fractures. The diagnosis and clinical course of an isolated splenic injury is variable.

Depending on the extent of injury and rate of blood loss, splenic injury cases can be divided into three groups:

1. Severe type of trauma.
2. Mild to moderate type.
3. Delayed type of case.

(1) Severe Type of Trauma: With patients succumbing rapidly and never rallying from the initial shock. Spleen blood loss is approximately 5% of the cardiac output i.e., 300 cc/min. So a large laceration through body of spleen can extend into splenic pedicle, causing extensive and continued haemorrhage, abdominal distension with haemoperitoneum and shock. Such injuries are fatal within minutes.

(2) Mild to Moderate type of Trauma: These are injuries presenting with initial shock. A laceration deep in the pulp or an adhesion between spleen and its ligaments or diaphragm causes avulsion with cessation of haemorrhage after an initial blood loss of 500 to 700 cc. These cases are common and they present with initial shock and once it has passed off, there are signs which point to intra-abdominal bleeding.

Following are clinical features which are seen in such cases:

a) General Signs b) Local Signs

(a) General Signs:

General signs or intra-abdominal bleeding are variable and will depend on extent /rate of bleeding / cardiovascular status of patient, pre-trauma haemoglobin levels and efficiency of homeostatic mechanisms. Perhaps most helpful of the general signs are those seen after any haemorrhagic shock i.e., pallor, tachycardia, sighing respiration, perspiration and restlessness.

(b) Local Signs:

These are caused by presence of blood in the peritoneal cavity.

1. Abdominal guarding especially in left hypochondrium is positive in more than 50% of cases.
2. Local bruising and tenderness in left upper quadrant of abdomen.
3. Abdominal distension, caused by blood in peritoneal cavity causing paralytic ileus. It usually commences after about 3 hours of accident.
4. Kehr's Sign: Which is pain referred to the tip of left shoulder. It is inconstant, varying in incidence from 15-75% and is unreliable probability, if present. It is elicited by bimanual compression of left upper quadrant after patient has been in Trendelenburg position preceding the manoeuvre. It is caused by blood in contact with the undersurface of the diaphragm and pain being mediated through afferent fibres in the phrenic nerve.
5. Ballance's Sign: It is positive in 25% of cases. There is a dull note in both flanks, but on right side it can be made to shift, whereas on the left it is constant. There may be a palpable tender mass in left upper quadrant. It is caused by extracapsular or subcapsular haematoma with omentum adherent to the injured spleen.
6. Bogginess in the Pouch of Douglas: On per – rectal examination, due to blood or clots in the rectovesical puch.

Though, these signs have been described, they might not be present in all patients. Continued observation is therefore, required and high degree of suspicion maintained. There are no symptoms specific to the splenic trauma. Patient might either have general symptoms due to shock (restlessness, vomiting) or local symptoms (pain, respiratory distress, pain radiating to left shoulder tip, hiccups).

(3) Delayed Typed of Trauma: After initial signs have passed off, the symptoms of serious intra-abdominal catastrophe are postponed for a variable period upto 15 days, or even more. As a rule, it is only a matter of minutes to an hour or so, during which time the patient often appears to have recovered from internal haemorrhage. The cause of delayed haemorrhage is local vasoconstriction with or without formation of blood clot which seals the tear or formation of subcapsular haematoma at the onset, which has potential to rupture at a time remote from injury-accounting for the phenomenon of delayed rupture of spleen. The causes of such haemorrhage are those of reactionary or secondary haemorrhage.

INVESTIGATIONS

- Haematological Investigations: Changes in blood are seen due to haemorrhagic shock. There is usually anaemia depending on degree of blood loss and haematocrit value is 10% to 3% below normal and there is moderate leucocytosis.
- Radiological Investigations:

(A) Plain X-ray of Chest and Abdomen in standing position

The radiological signs of splenic rupture on plain X-ray are-

i. Obliteration of splenic outline.
ii. Obliteration of psoas shadow.
iii. Indentation of left side of gastric air bubble.
iv. Fracture of one or lower ribs on the left side (present in 27% of cases).
v. Elevation of left side of diaphragm.
vi. Free fluid between gas filled intestinal coils.
vii. Left sided (sympathetic) pleural effusion.

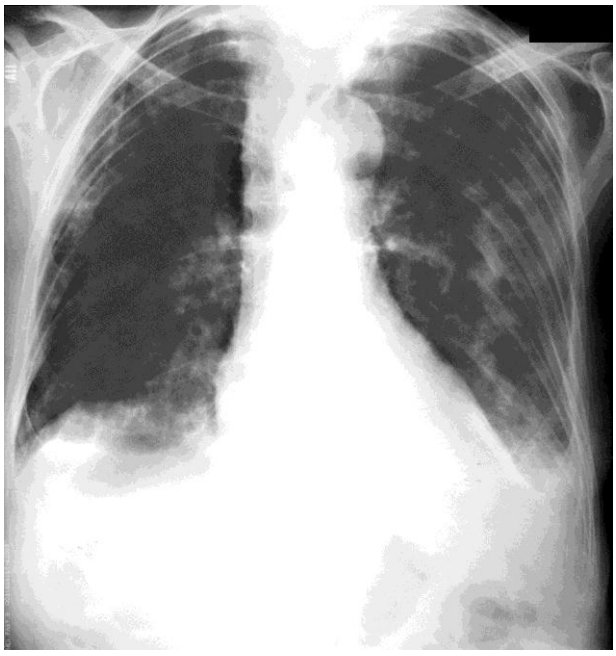

Fig 5: X – Ray Showing Fracture of Multiple Left Ribs

Patient may have ground glass appearance due to blood in abdominal cavity but this can be due to any source of intra-abdominal bleeding and is not specific to splenic trauma.

Plain X- ray study not only helps to suspect splenic trauma but also helps in suspecting and identifying associated injuries in patients with blunt trauma which is mandatory e.g. gas under diaphragm if there is associated bowel perforation or pneumothorax, lung contusion associated with rib fractures.

These findings can change plan of management hence should be done in all patients of blunt trauma.

(B) Ultrasonography (USG)[1,3,13]

USG plays an important role in planning management in a case of blunt abdominal trauma. It is portable, cheap and easily available. It can detect splenic laceration contusion and sub capsular haematomas. It shows free fluid within abdominal cavity. It can also detect associated other solid organ injury e.g, liver/kidney. Few limitations of USG being, it is operator dependent, have poor resolution in presence of obesity, bowel gas, subcutaneous emphysema. Despite these limitations, it can be useful in the management of patients with splenic trauma. Patients who have been put on conservative treatment can be monitored by follow-up USG.

Focused abdominal sonographic technique (FAST)

Six standard areas are examined.

- Right paracolic gutter
- Left paracolic gutter
- Pericardium
- Perisplenic region
- Suprapubic region
- Morrisons pouch

FAST, observing for the presence or absence of fluid in the peritoneal cavity may be performed rapidly and safely in trauma patients.

FAST is poor for delineating organ-specific anatomy with any reliability in the emergency setting. In addition, the learning and interpretation curve is rather steep when compare to DPL.

In experienced hands, visualization of fluid in the right upper quadrant, the left upper quadrant, and the pelvis suggest solid organ injury (Mesenteric injury) and the possibility of splenic injury.

(C) CT scan Abdomen[18,23,32,33]

CT abdomen with IV contrast is currently the preferred imaging modality in the radiographic workup of these type of patients Findings of CT includes – subcapsular haematoma, intrasplenic haematomas, splenic lacerations and occasionally infarction. Subcapsular haematoma has the appearance of a crescentic low density collection, hugging the lateral splenic margin.

A laceration is an irregular linear defect that should not be confused with a splenic defect, which is a sharp, smooth, linear defect. Blood is usually present around the spleen and in the pelvis. With episodes of intermittent bleeding, the haematoma may have an 'onion skin' appearance. Even if a clear splenic defect is not visualized, high density fluid around the spleen, is an important sign of injury. This is owing to the density of blood.

CT is also a good method to follow healing in a patient who is treated conservatively. Healing time will depend on the severity of the injury. CT scan also helps in identifying and grading of other solid organ injuries. A splenic blush noted by a helical CT scanner has a greater propensity to require splenic exploration in most series.

Disadvantage of CT is that, it is not portable, requires stable patient and need for administration of contrast and procedure is costly.

- MRI has not proven useful in initial evaluation of abdominal trauma.
- Interventional Investigations:

These include-

- Abdominal paracentesis.
- Diagnostic peritoneal lavage.
- Diagnostic laparoscopy

(A) Abdominal Paracentesis:

Needle paracentesis was used in early 1960's It was incorporated as a method of determining intraperitoneal haemorrhage in comatose patients. It involves tapping of peritoneal cavity with long needles and examination of fluid. Gross freely flowing blood which does not clot is diagnostic of intraperitoneal bleed. When positive, the test is highly predictive of significant intra-abdominal injury. Unfortunately false negative rates are high. Though positive test is predictive, a negative test should not be considered as confirmatory for no intraperitoneal bleeding and other diagnostic modality should be used to confirm absence of intraperitoneal bleeding e.g, USG guided aspiration, CT scan, diagnostic peritoneal lavage.

(B) Diagnostic Peritoneal Lavage (DPL)[26,28]

Sensitivity of DPL being 95% and specificity 98-99% and accuracy of 97% DPL remains the mainstay for diagnosis of intraperitoneal haemorrhage in unstable patients. It is also useful in patients in whom sequential examination will be impossible e.g, patients with polytrauma undergoing extensive procedure such as multiple fracture fixation.

There are 3 methods for doing DPL-

- Closed
- Open
- Semi-open

(a) Closed:

Inserting catheter in blind percutaneous fashion. It has the disadvantage of uncontrolled depth of penetration with potential risk of damage to intra / retroperitoneal structures.

(b) Open

It involves traversing abdominal wall under direct visualization. It is safe compared to closed technique but it introduces air in peritoneal cavity and is time consuming.

(c) Semi – open

It involves reaching till peritoneum under vision and then introducing catheter blindly. It has advantage of being quick, easy and reliable.

Method

- Stomach and bladder are deflated by using Ryle's tube (RT) and Foley's respectively.
- Periumbilical area is shaved and prepared.
- Local anaesthesia is infiltrated in infraumbilical area.
- A gently curved incision is made at level of infraumbilical ring and carried down till level of linea Alba.
- 5 mm incision is then made on linea Alba and free edge grasped with towel clips.
- Standard dialysis catheter with its trocar is inserted into the peritoneal cavity towards floor.
- 1 liter (5 mi/kg) of warmed 0.9% NaCl Solution is infused.
- Patient is rolled from side to side.
- Saline bag lowered to floor for return of lavage fluid
- Minimum 75% recovery of lavage effluent is required for test to be reliable.
- Fluid is sent for RBC/WBC/lavage amylase/ alkaline phosphatase/ bile.

Disadvantages of DPL: It does not sample intact retroperitoneum and may not adequately reflect isolated hollow visceral or diaphragmatic perforation. It may include perforation of small bowel, mesentery, bladder, retroperitoneal vascular structures.

Criteria for Positive DPL following Blunt Abdominal Trauma are

Index	Positive	Equivocal
Aspirate		
Blood	> 10 ml	
Fluid	Enteric contents	
Lavage		
RBC's	> 1,000,000/mm^3	> 20,000/mm^3
WBC's	> 1,000,000/mm^3	> 500/mm^3
Enzymes	Amylase > 20 IU/L	Same
	Alkaline Phosphatase > 3 IU/L	
Bile	Confirmed biochemically	

(C) Diagnostic Laparoscopy[6,34]

Laparoscopy carries a high diagnostic yield in the identification of intra-abdominal injuries and by exclusion of significant intra-abdominal trauma, it reduces the negative laparotomy rate.

MANAGEMENT OF SPLENIC INJURIES

Once a patient has been diagnosed to have a splenic trauma, the modality of management will be decided by haemodynamic status of the patient, grade of splenic injury, age of patient, associated injuries, facilities especially, blood bank, intensive care available.

(1) Total Splenectomy

It is the time honoured choice of treatment for splenic injuries. Despite segmental arrangement of splenic arterial supply, as described in portion on anatomy of spleen, the friability of spleen often renders repair or partial resection impossible. The primary indication for splenectomy following trauma are:

(a) Hilar vascular injury.
(b) Massive subcapsular haematoma.
(c) Extensive fragmentation.
(d) Total avulsion of spleen.
(e) Severe associated injuries requiring prompt attention.
(f) Continued bleeding after attempted splenic repair/conservation.

In patients with multiple intra-abdominal injuries or extensive peritoneal contamination from visceral perforation, it is prudent to weigh the benefits of splenic salvage against the safer course of splenectomy.

Technically splenectomy in traumatic spleen requires a quick mobilization. The hand is passed around the outer surface of spleen; the posterior layer of lienorenal ligament is divided largely by blunt dissection. And the spleen rotated medially into the incision. A large pack is inserted and short gastric vessels and those in pedicle are ligated and divided. It is important to separate tail of pancreas from the vessels in the hilum before ligation.

Postoperative complications

(i) Haemorrhage – if a ligature slips off the splenic vessels.
(ii) Gastric dilatation – following partial mobilization of stomach when ligating the short gastric vessels.
(iii) Haematemesis – may rarely occur possibly due to mucosal damage to the stomach when ligating short gastric vessels.
(iv) Left basal atelectasis – sometimes a pleural effusion is common. This may be due to damage to or irritation of the left hemidiaphragm or subpleuric abscess and may be accompanied by persistent cough.
(v) Damage to tail of pancreas – during mobilization of splenic pedicle, this may produce a localized abscess or if the area has been well drained, a pancreatic fistula. This may be associated with a left pleural effusion or abdominal wound dehiscence.
(vi) Splenectomy is frequently followed by a rise in the WBC and platelet count, a few days after operation. There may be risk of thrombosis if the platelet count rises above 1000 X 10^9 / liter and it is to anticoagulate patient.
(vii) Gastric fistula – due to damage to greater curvature of stomach when ligating short gastric vessels.
(viii) Overwhelming post splenectomy sepsis.

(2) Partial Splenectomy and Splenorrhaphy[15,21]

The segmental anatomy and blood supply of spleen makes splenic salvage a possibility. Most of the splenic injuries result in various degrees by transverse rupture of the spleen following the trabecular and segmental blood supply.

Indications: Stable patient with minor associated injury.
: Isolated splenic injury Grade – I to IV

Contraindications: Unstable patient.
: Diseased spleen.

Suturing of splenic tissue which is highly vascular and friable is difficult. However, spontaneous haemostatic control within the sinusoids by reduction in arterial inflow allows for safe reconstruction by placement of sutures through the capsule. This is more effective in children than in adults as there is greater ratio of capsule to splenic pulp in children.

Methods

(a) Small capsular tear or avulsion
- Use of microfibrillar collage, thrombin, fibrin biologic gules.
- Argon beam cautery – coagulation.

(b) Parenchymal fractures or laceration
- Application of transverse mattress sutures over cut pledgets to reappose the cut surface of spleen.
- Figure of 8 sutures.

(c) Significant injuries with large parenchymal lacerations
- Partial resection.
- Complete wrapping of spleen in absorbable mesh[15] compression bag.
- Large through and through horizontal mattress sutures that are inserted perpendicular to the plane of injury.

Successful splenorrhaphy requires complete mobilization of spleen. The splenic pedicle is approached through gastrosplenic ligament and vessels in the hilus of spleen supplying the injured portion of the spleen are ligated. Demarcation of the devascularised segment becomes apparent, allowing accurate segmental resection of the injured tissue.

Most large urban centres report splenic conservative procedure rates between 40-60%.

(3) Auto transplantation[12,35]

Autotransplantation of splenic tissue should be considered only when there is no other way to preserve splenic function. The splenic tissue is reimplanted into an omental patch. This tissue initially undergoes necrosis followed by regeneration this procedure does not substitute for non-operative or splenorrhaphy. However, it is becoming a simple and logical alternative following splenectomy.

(4) Non- operative Management[5,8,9,22,24,40]

The safety and effectiveness of non-operative management of selected adult and paediatric patients with isolated splenic injuries have been confirmed by numerous reports.

Non-operative management is successful in children because of the haemostatic properties of the splenic capsule in children. The capsule in children is thicker and contains some myoepithelial cells which may have constructive properties.

Indication : No Period of haemodynamic instability.
No peritoneal findings any time.
Blood requirement less than 2 units.

Pre-requisite: Intensive care facility.
Repeated CT scan and USG facility.
Equipped blood bank.

Factors that predicts failure of non-operative management for blunt splenic injury[2,25,32]

- Hemodynamic instability
- Grade of injury
- Size of haemoperitoneum
- Contrast blush on CT or Vascular blush on CT
- Age older than 55yrs

The risk of delayed splenic rupture in these patients is small but must be considered and patients must be cautioned accordingly. Another consideration in non-operative management is the possibility of an unrecognized associated intra-abdominal injury.

Isolated injuries of Grade I, II and III who above criteria are candidates for non – operative management, although any patient meeting the haemodynamic stability requirement, regardless of CT image, is a potential candidate for observational management.

LATEST TRENDS IN SPLENIC INJURY MANAGEMENT[12,20,34]

"Splenectomy is recommended treatment regardless of type or extent of splenic injury", a statement by Schwartz is changing to "spleen should be preserved whenever possible".

Morrell et al[20], studied that non-operative conservative management is the treatment of choice if the patients are haemodynamically stable, if there are no associated intra-abdominal injuries and if no extra-abdominal injuries precludes assessment of abdomen. Isolated injuries of spleen Grade-I, II and III who meet the above criteria are candidates for non-operative management.

Delayed haemorrhage and/or occult rupture are dreaded complications of conservative management, however incidence of these, are rare.

Conservative management requires constant monitoring to detect any episode of hypotension. No patient requiring more than 3 units of blood should be managed by this method.

Laparoscopy plays an important role in diagnosing intraabdominal lesions in trauma and by its principle of exclusion of significant injury, reduces the negative laparotomy rate.

Splenectomy is the treatment of choice for all Grade-IV and V injuries or with associated significant intra-abdominal lesions. Keeping in mind, the immunological role of spleen, splenic transplants are made in greater omentum and regular follow – up radionuclide scans are done to assess the functional take over.

Splenic conservation is the goal in treating paediatric splenic injuries. However, conservative management requires CT scan facility and availability of fresh blood and good intensive care back-up for continuous monitoring.

Role of Laparoscopy in Splenic Trauma[34]

Standard diagnostic methods for assessment of splenic rupture are DPL, CT scan and USG but these have a number of shortcomings that may be overcome by laparoscopy.

A study by Targarona E.M., Trias M. et al confirm that laparoscopy for abdominal trauma carries a high diagnostic yield in the Identification of intra-abdominal injuries and by exclusion of significant intra-abdominal trauma, it reduces the negative laparotomy rate.

Therapeutic laparoscopy can be used to deal with mild splenic lesions in stable patients and in treatment of late consequences of splenic injury such as post-traumatic abscess or pseudoaneurysms.

Management of Paediatric Splenic Trauma

Traumatic injury is the leading cause of death in children of all ages, adolescents having the highest proportions and severity of injuries.

The commonest modest of injury being

- Traffic accident
- Bicycle accident
- Assaults
- Common in older (> 2 years) abused children

Once the child is haemodynamically stable, they are subjected to USG or CT scan. CT scan is an accurate means to detect the grade of splenic injury, other associated injuries and presence of free intra- abdominal fluid.

With knowledge of role of spleen in immunology, the management of paediatric splenic injury is mainly conservative, splenic salvage being the goal. Non- operative management is done in children who have had no evidence of hypotension and who have isolated splenic injury.

In those patients requiring surgery, the spleen may be preserved by splenorrhaphy, or partial splenectomy or autotransplantation in greater omentum.. Subsequent scans of these patients reveal a slow take-over in the function of spleen. Tristan et al, have mentioned selective splenic artery embolisation or use of polyglycolic acid mesh in children with splenic trauma.

EFFECTS OF SPLENECTOMY (ASPLENIC STATE)[4,10,14,16]

Immediately following splenectomy, the platelet count rises by about 30%. It remains elevated for 2-10 days postoperatively, reaches the peak by 2-3 weeks and slowly comes to normal. The peripheral smear shows abnormal red cells with nuclear remnants like Howell- Jolly bodies and target cells. There is a fall in IgM and complement 3, and properdin, such a patient shows poor response to intravenous immunization with particulate antigen.

Overwhelming post-splenectomy infection (OPSI) is the most hazardous complication following splenectomy. Due to deficient clearance of the particulate antigens, deficiency of the phagocytosis and depressed immunity, as a result of fall in IgM, complement 3 and properdin, splenectomised subject is more prone to infection. Although, no age is exempt, most frequent occurrence is in children below the age of 2 years and within first 2 years of splenectomy. Overall incidence is often seen after splenectomy for thalassemia, portal hypertension and hypersplenism.

Although, the incidence of OPSI after splenectomy for trauma is low (0.05%) there is however, definite risk.The organisms most commonly responsible for this infection are the capsulated organisms namely D. Pneumoniae, H. influenzae ; although N. meningitis, E. coli, Pseudomonas have also been noted.

The infection may take the form of an abscess, pneumoniae, meningitis or peritonitis. Ultimately all these lead to fulminant

septicaemia, which leads to death within 12-24 hours of onset due to disseminated intravascular coagulation, shock or adrenal haemorrhage.

PREVENTION OF OPSI

1. Immunisation: For planned splenectomy, immunization with pneumococcal vaccine, 1-2 weeks prior to operation followed by a 1 yearly booster, postoperatively has been described. For emergency splenectomy, it's use has been recommended within 72 hours. But it offers protection against specific subtypes and is of limited value.
2. After splenectomy, patients over the age of 2 should be vaccinated against H. influenza, S.pneumonia, and meningococcus. At present, there is no clear data on the best time to give the immunizations. Pneumococcal vaccination should be repeated every 6-10 years. Children should be placed on daily penicillin prophylaxis until at least age 5. Many pediatric surgeons would continue prophylaxis until age 18. The use of splenic autotransplantation for prevention of OPSS has been proposed.
3. Long term antibiotic prophylaxis has been frequently used. Infection can occur still with resistant organisms and this is its major drawback.
4. Patient education is important and he or she must learn about the early sign of infection. All infections including the minor ones need to be treated aggressively.
5. Avoid splenectomy if you can. This is the best option whenever feasible. One of the commonest indication for which splenectomy can be avoided is trauma to the spleen.

Spleen remains the most commonly injured intra-abdominal organ in patients who have suffered blunt abdominal trauma. Splenic trauma constitutes a broad spectrum of injuries ranging from minor lacerations with minimal bleeding that requires little or no interventions, to massive injuries , shattered or avulsed spleen. The rise in modern means of transport has led to rise in abdominal trauma and hence resulting in an increase of splenic injuries. However, mortality from splenic trauma has decreased over the past decade, which can probably be attributed to faster patient transportation from site of trauma to the hospital, improved methods of resuscitation, intensive care, anaesthetist and post-operative care. The advent of diagnostic techniques such as USG and CT scan has helped us to understand the nature course of spenic trauma.

In our study, 40% patients with splenic trauma are between 21 to 30 years of age. Third decade of life represented maximum splenic injuries. Mean age of presentation is 28.5 years. In cocanour CS et al series the mean age of presentation is 35.3years. In our series 90% of patients are males and only 10% of patients are females. In cacanour series CS et al series 90% of patients are males, 10% of patients are females. Males are more affected with splenic injury. In our series road traffic accidents causing blunt trauma accounted for 66.67% of patients, 23.33% of patients presented with injury due to fall from height and 10% of patients due to an assault.

The minimum lapse time was 1 hr in our series and the maximum period was 9 hours. 80% of patients presented within 6 hours of injury. The patients who presented early within 2 hours have good outcome. The patients who presented late had higher complication rates. 72% of patients presented with stable vitals. 28% presented with unstable vitals. The patients were resuscitated thoroughly before taking for laparotomy with crystalloids and whole blood transfusion.

In our series 90% of patients presented with clinically positive abdominal signs, the most common symptom is pain abdomen and clinical sign is tenderness of abdomen associated with guarding and rigidity. Trauma over the left side of the abdomen and fracture left lower ribs are very valuable findings for the diagnosis of splenic trauma. Persistent fall of blood pressure inspite of resuscitation is a sure sign of internal bleeding. Abdominal paracentesis is a simple bed-side procedure which found very useful. In our study, abdominal tap was done in all patients and was positive in 72.5% cases.

Ultrasonography is a basic investigation in cases of blunt abdominal trauma. In our series, portable USG was done in all patients and 86.6% cases were positive. In haemodynamically stable patients, CT scan plays an important role in picking up concealed injuries and hence assists in deciding the management. In our series, a large number of patients suffered from Grade I and Grade III splenic injuries mainly as a result of associated left sided blunt chest trauma. The incidence of splenectomy was 50% because 26.67% suffered Grade III injuries, 13.33% suffered Grade IV injuries and 6.67% suffered Grade V splenic injuries , in which case splenic salvage procedure was not possible.

40% of patients managed non operatively and 60% are manage operatively. 3% of patients are initially managed non operatively and then explored later in view of hypotension with splenectomy. 26.67% patients required less than 2 units of blood transfusion. Due to a well-equipped blood bank and fresh blood availability , non of the patients suffered from inadequacy of management due to deficit of blood. All the patients in our study who had undergone splenectomy were given injection Pneumovac and Penidura prophylaxis. 10% patients expired in our series, mainly due to head injury and associated fracture of long bones, one patient expired due to post-operative malarial infection. None of the patient died due to non-operative management.

INCIDENCE OF GRADE OF SPLEENIC INJURY

GRADE OF SPLEENIC INJURY	ZUCKER et al (n = 68)	OUR SERIES (n = 30)
I	19	12
II	28	4
III	17	8
IV	4	4
V	0	2

In Zucker et al series grade – I and grade – II injuries are commonly involved accounting to 70% of patients. In our series grade – I & grade – III injuries are more commonly involved accounting to 77% of patients.

In Myers et al[24] series 68 out of 204 were non operatively managed and success rate of non-operative management is 93 % and failure rate is 7 %. In Zucker et al[41] series 24 out of 68 were non operatively managed and success rate of non-operative management is 95 % and failure rate is 5 %. In Cocanour et al[5] series 57 out of 311 were non operatively managed and success rate of non-operative management is 86 % and failure rate is 14%. In our series 12 out of 30 were non operatively managed and success rate of non-operative management is 92 % and failure rate is 8%.

MANAGEMENT PROCEDURE

STUDY GROUP	MYERS et al[24]	ZUCKER et al[41]	COCANOUR et al[5]	OUR SERIES
Total no. of patients	204	68	368	30
Operative	136	44	311	18
Non-operative	68	24	57	12
Non-operative success %	93 %	95 %	86 %	92 %
Non-operative failure %	7 %	5 %	14 %	8 %

CONCLUSIONS

The flowing conclusions are drawn from the findings of the present series of splenic trauma :- The common age group affected by trauma is of young working class men. This produces loss of working hands to the nation and affects its economy. Increase in high speed traffic and industries in urban India have given rise to marked rise in accidental injuries. Time lapse between injury and treatment has significant association with outcome. Patients who present with less than 2 hours of injury are having better prognosis with less morbidity and mortality. Grade of splenic injury, continuous monitoring of patient and associated injuries have direct bearing on outcome. Preoperative Ultrasound scan of abdomen and pelvic cavity is diagnostic of splenic injury with a sensitivity rate of 86.6%. In haemodynamically stable patient, CT scan offers best modality to decide line of management. Abdominal paracentesis is very useful in diagnosis of intra-abdominal injury. The method is very much reliable and carries no risk. Overall splenic injuries of Grade1 and Grade 2 have good out come with non-operative management when not associated other injuries. Grade 4 and Grade 5 splenic injuries treated surgically gives excellent results. In multiorgan injury, results of treatment are poor. Prophylactic antibiotics will prevent post-operative complications. Pneumococcal vaccine prevent over whelming post splenectomy infections. Failure of non-operative management is due to haemodynamic instability, age older than 55 years, contrast vascular blush on CT scan. With better understanding of the role of spleen in body immunology, the management of splenic trauma has changed in last two decades and today splenic salvage is the goal. Various treatment options for splenic trauma are: Non-operative treatment, conservative surgery and splenectomy. One has to weigh the risks of exsanguinations, which is immediate, against that of OPSI, which may occur later.

Splenectomy is the treatment of choice for haemodynamically unstable patient, patient with polytrauma, severe grade of splenic injury, and pathological spleen with injury. Splenic injuries can be successfully treated non-operatively in children in centres where close monitoring is possible, emergency surgical intervention can be done back -up facilities exist. Laparoscopy for abdominal trauma carries a high diagnostic yield in the identification of visceral injuries.

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