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A prospective analysis of intra-abdominal pressures and outcome in patients undergoing emergency laparotomies

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Abstract
Background: As many studies have been done upon IAP and its outcome on the patients that Intra-Abdominal Hypertension (IAH) leaves an impact on every organ. In recent times it is strangely under diagnosed. Although IAP is an independent predictor in measuring the morbidity and mortality.
Aim and Objectives: To evaluate changes in various clinical parameters due to increasing Intra-abdominal Pressure and also to evaluate the Morbidity and Mortality in patients who develop abnormal Intra-Abdominal Pressure
Methodology: The present study was a prospective analysis of IAP in patients presenting to surgical emergency of Mahavir Institute of Medical Sciences, Shivareddypet, Vikarabad, Ranga Reddy -Telangana, India.over a period of 1year from December 2019 to December 2020. A total number of 40 patients were assessed with regards to their clinical diagnosis, vital parameters al presentation, IAP and the morbidity and mortality. The SEDREK'S Technique of IAP measurement was used to determine the IAP. In this method, the Foleys catheter is marked as '0', few mm proximal to the Y-junction, which serves as the zero reference point when it is at the level of symphysis pubis.The drainage tubing is marked at an increment of 1 cm on the tape, starting from the mark on the foley's catheter as '0'. Next introduce 50 to 100 ml of sterile saline into the bladder. After reconnecting the Foley's catheter to the drainage tubing, the zero reference point is kept at the level of pubic symphysis and the drainage tubing is raised vertically.
Result and Conclusion: IAP was found to be a significant predictor of mortality in patients undergoing laparotomy (P<0.001). Elevated IAP was found to affect all the organ systems adversely. The incidence of post-op ACS was 3.05% in the general population and 13.16% in trauma patients. The mortality rate for this subgroup was 100%**.** Out of a total number of 40 patients 18 patients belonged to this category which is 45%. 5 patients were diagnosed with two day history of intestinal obstruction, 5 patients with two day history of peritonitis, 7 patients with one day history of peritonitis and 1 patients with ruptured liver abscess. The clinical condition of this particular subset of patients was relatively stable when compared to the patients in the other Grades. The average pulse rate was 96/mt, the average systolic blood pressure 98 mmhg and the average respiratory rate 15/mt. Post operative recovery was uneventful without any complication in 14 cases, 4 patients had wound gaping which could be due to other factors.
Hence this study demonstrates that increase in Intra-Abdominal Pressure causes a change in different clinical Parameters. Grade 4 Intr-Abdominal Pressure is associated with Abdominal compartment syndrome and hence with very high mortality. Measurement of Intra-Abdominal Pressure by the Sedrek's technique is easy, reliable and can underlying physiological status. Intra-Abdominal Pressure measurement can be used as an independent clinical parameter to assess the patients current clinical condition.

Keywords: Intra-abdominal pressure (IAP), intra-abdominal hypertension (IAH), abdominal compartment syndrome (ACS), Sedrek's technique, emergency laparotomies

Introduction
However, the recognition of abdomen as a compartment and the concept of intra abdominal hypertension (IAH) resulting in abdominal compartment syndrome (ACS) have only recently received attention. Korn and associates first used the term abdominal compartment syndrome in 1980 [1]. The effect of the increased intra-abdominal pressure in various organ systems has been noted over the past century. Emerson first noted the cardiovascular morbidity and mortality associated with elevated intra-abdominal pressure in 1911 [2]. It is only in the past decade, that the pathophysiological repercussions of the increased intra abdominal pressure (IAP) and (ACS) have been recognized in a wide spectrum of surgical patients and treated aggressively. More recently, the wide spread use of laparoscopy has highlighted the consequences of increased intra abdominal pressure.

Increase in the IAP results in decrease in cardiac output due to drop in preload and increase in after load. It most commonly seen at an IAP>20mm of Hg [3]. IAP is the pressure concealed within the abdominal cavity. Although IAP can physiologically reach elevated values transiently up to 80 mm Hg (cough, Valsalva maneuver, weight lifting, etc.), these values cannot be tolerated for long periods [4, 5]. Normal IAP is approximately 5–7 mm Hg in critically ill adults. IAH is defined as an intra-abdominal pressure above 12 mm Hg. The presence of IAH is associated with an 11-fold increase in mortality compared with patients without IAH.The detrimental effects of IAH occur long before the manifestation of compartment syndrome. The ACS, therefore, should be viewed as the end result of a progressive, unchecked increase in IAP from a myriad of disorders that eventually leads to multiple organ dysfunction. Rapid progression of IAH leads to ACS, which is defined as an IAP greater than 20 mm Hg with at least one new organ system dysfunction/failure. Elevated IAP produces multiple derangements in both intra- and extra-abdominal organs. While adverse effects on kidneys and lung have been well recognized, subsequent studies have documented an impact on virtually every organ except the adrenal glands. But there are always two sides to a coin, and IAP is no different.

Aims of the study

1. To evaluate changes in various clinical parameters due to increasing Intra-abdominal Pressure.
2. To evaluate the Morbidity and Mortality in patients who develop abnormal Intra-Abdominal Pressure

Materials and Methods

The present study was a prospective analysis of IAP in patients presenting to surgical emergency in Mahavir Institute of Medical Sciences, Shivareddypet, Vikarabad, Ranga Reddy - Telangana, India .A total number of 40 patients were assessed with regards to their clinical diagnosis, vital parameters al presentation, IAP and the morbidity and mortality.

The SEDREK'S Technique [12, 13 ,14]. of IAP measurement was used to determine the IAP. In this method, the Foleys catheter is marked as '0', few mm proximal to the Y-junction, which serves as the zero reference point when it is at the level of symphysis pubis.

The drainage tubing is marked at an increment of 1 cm on the tape, starting from the mark on the foley's catheter as '0'. Next introduce 50 to 100 ml of sterile saline into the bladder. After reconnecting the Foley's catheter to the drainage tubing, the zero reference point is kept at the level of pubic symphysis and the drainage tubing is raised vertically.

The transition from horizontal to vertical at '0' mark and should not be too abrupt. The distance the sterile saline raises vertically in the tubing is measured in centimeters and 1.36 cm of length is equivalent to 1 mm hg.

By this method the pressure can be measured hourly and is simple to do.

Patient were included in the study only after a decision to operate upon him/her was taken. Patient particulars were noted along with the indication for surgery. Readings were taken preoperatively and then postoperatively at 0, 6, 24, and 72 hours. If IAP remained below 12 mm Hg, measurements were discontinued after 24 hours.

Parameters noted were

1. blood pressure,
2. pulse rate,
3. respiratory rate,
4. oxygen saturation (SpO_2),
5. temperature,
6. urine output,
7. IAP,
8. duration of surgery,
9. per-op findings,
10. duration of hospital stay,
11. morbidity (burst abdomen), and
12. Mortality.

Following laboratory investigations were conducted

1. blood urea and
2. serum creatinine.

Measurement of intra-abdominal pressure

The abdominal pressure was indirectly determined by measuring urinary bladder pressure with a Foley's catheter. Patient was catheterized with a 16-guage Foley's catheter. The bladder was drained and then filled with 50 ml of sterile saline through the Foley's catheter. The tubing of the collecting bag was clamped. The catheter was connected to a saline manometer. The symphysis pubis was the zero reference, and pressure was measured in centimeters of water at end-expiration. A conversion factor of 1.36 was used to convert the pressure into millimeter of Hg. The IAP measurements had some limitations in our study.

Measurement via a Foley bladder: A standard intravenous infusion set is connected to 1000ml of normal saline, two stop-cocks, a 50ml Luer lock syringe and a disposable transducer. A plastic Y Piece connector (7*7*7mm, Porges France) is inserted just after culture aspiration port of the Foley catheter, and connect to the infusion catheter with a luer lock adapter. This fusion catheter is attached to the first cock via arterial pressure tubing after being flushed with saline and "zeroed" at the level of symphysis pubis . The Foley catheter is clamped immediately distal to Y-piece. The stop cocks are turned "off" to the patients and pressure transducer and 50ml of saline is aspirated form the intravenous bag. The first stop cock is turned "on" to the patients and the 50ml of saline are instilled into bladder. The stopcocks are turned "off" to the syringe and the intravenous tubing. After equilibration the patient's IAP is then measured at the end-expiration on the bed side monitor. To verify correct measurement gentle compression of the abdomen should oscillate. Care must be taken not to over distend the bladder , ideally limiting the volume to 50ml or less to avoid detrusor activity. After equilibration the patient's IAP is measured at end-expiration on the pressure transducer [6] Figure 1.

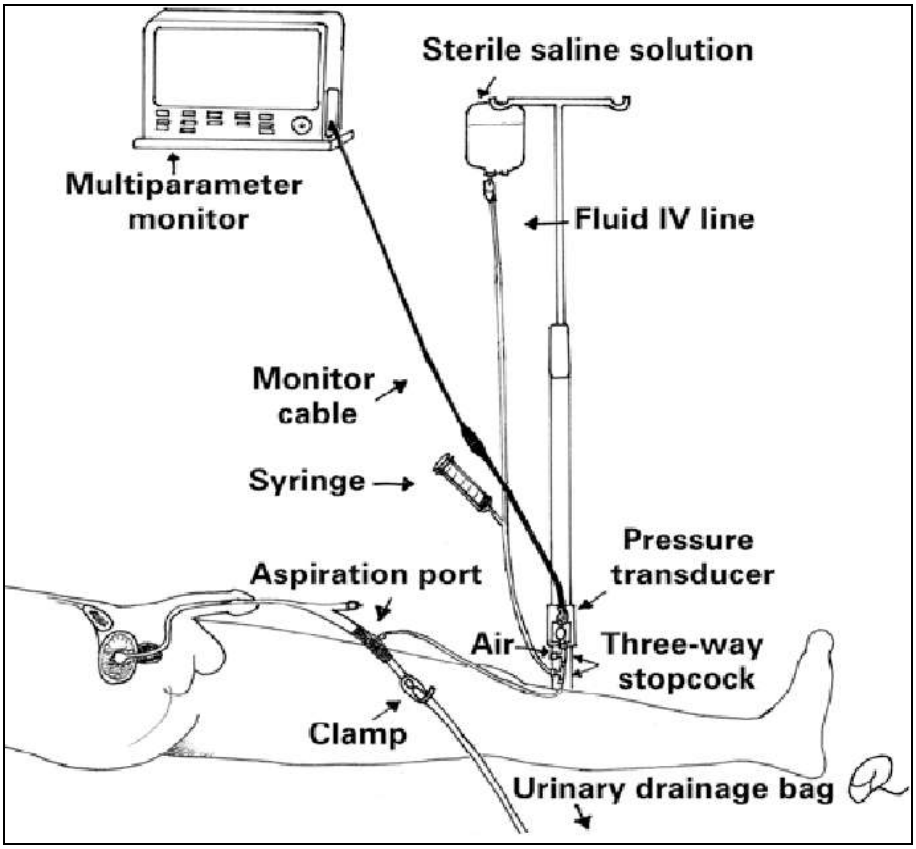

Fig 1: Intra-abdominal pressure measurement using the pressure transducer

IAP can also be measured directly at laparoscopy.
The Grading of IAP as proposed by BURCH & MOORE was used to interpret the measurements.

Grading of intra-abdominal hypertension

1. Grade I: 12–15 mm Hg;
2. Grade II: 16–25 mm Hg;
3. Grade III: 26–35 mm Hg; and
4. Grade IV: >35 mm Hg.

The term "abdominal compartment syndrome" was used when IAH was associated with at least one newly developed organ system dysfunction.
In patients with ACS, the decision to proceed with decompressive laparotomy lays in the hands of the primary surgeon in-charge of the patient.

Abdominal compartment syndrome (ACS): Is defined as sustained IAP greater than 10 mmHg, with or without abdominal perfusion pressure less than 60mmHg13 and the onset of new or worsening organ failure directly attributed to elevated IAP. The syndrome is associated with 90%-100% mortality if not recognized and treated in a timely manner.

Abdominal perfusion pressure (APP): APP = Mean Arterial Pressure (MAP) – IAP. In adults keeping this greater than 50-60mmHg significantly improves morbidity & mortality. The appropriate APP for children is unknown, but will be less than the adult level due to a lower MAP.

Primary IAH or ACS: Is a condition associated with injury or disease in the abdominopelvic region that frequently requires early surgical or interventional radiological intervention

Secondary IAH or ACS: Refers to conditions that do not originate from the abdominopelvic region

Assessment of risk factors for elevated Intra-abdominal pressure

- Diminished abdominal wall compliance
- Major trauma & burns; acute respiratory failure; abdominal surgery
- Increased intra-luminal contents
- Gastroparesis; ileus; pseudo-obstruction
- Increased abdominal contents
- Ascites/ liver dysfunction; Haemoperitioneum/ pneumoperitoneum;
- Capillary leak/fluid resuscitation
- Acidosis (pH<7.2); hypotension; hypothermia (under 33 degrees C); massive fluid resuscitation; poly transfusion; coagulopathy; sepsis, major trauma & burns.

Management

IAP can be measured directly or indirectly.

- Direct measurement is obtained via a needle or catheter in the peritoneal space, and IAP is measured using a fluid column or pressure transducer system. This is the most accurate method but associated with side effects such as bowel perforation and peritonitis.
- IAP is usually measured indirectly via the patient's bladder. The changes in intravesical pressure demonstrate an accurate reflection of intra-abdominal pressure (IAP)
- Patients with two or more risk factors for IAH should have a baseline IAP performed and if elevated should have continued serial measurements
- IAP is measured 4 hourly or more frequently if IAP greater than 12mmHg or the patient is hypotensive, has decreased

urine output or a tense abdomen

- An increased IAP reading should be rechecked to ensure there is not a technical problem e.g. a blocked catheter
- If IAP greater than 12mmHg then medical management of IAH should be instituted in a timely manner to prevent further morbidity and mortality. Renal impairment can occur with IAP as low as 10-15mmHg.
- Medical management will not be discussed in detail in this document but involves improving systemic perfusion, measures to reduce IAP, and in refractory cases early abdominal decompression. Excessive fluid administration should be avoided as it is strongly associated with ACS. The patient will need close clinical monitoring of organ function

Result

IAP was found to be a significant predictor of mortality in patients undergoing laparotomy (P<0.001). Elevated IAP was found to affect all the organ systems adversely. The incidence of post-op ACS was 3.05% in the general population and 13.16% in trauma patients. The mortality rate for this subgroup was 100%.

Analysis Of Grade 1

1. Out of a total number of 40 patients 18 patients belonged to this category which is 45%.
2. 5 patients were diagnosed with two day history of intestinal obstruction, 5 patients with two day history of peritonitis, 7 patients with one day history of peritonitis and 1 patients with ruptured liver abscess.
3. The clinical condition of this particular subset of patients was relatively stable when compared to the patients in the other Grades.
4. The average pulse rate was 96/mt, the average systolic blood pressure 98 mmhg and the average respiratory rate 15/mt.
5. Post operative recovery was uneventful without any complication in 14 cases, 4 patients had wound gaping which could be due to other factors. as in Table 1

Table 1: Analysis of Results

No.	Diagnosis	BP	P.R.	U.O.	R.R.	IAP (mmHG)	Post Op. Complications
1	Ruptured liver abscess	110/70	92	200	12	11.76	Nil
2	Peritonitis (1 Day)	110/70	96	200	14	10.29	Nil
3	Peritonitis (1 Day)	90/50	100	200	14	13.79	Nil
4	Intestinal Obstruction	90/60	96	100	15	10.29	Nil
5	Peritonitis (1 Day)	100/60	90	200	13	11.76	Wound Gaping
6	Peritonitis (2 Day)	90/60	92	75	13	11.81	Nil
7	Peritonitis (1 Day)	90/50	110	90	14	13.43	Nil
8	Peritonitis (2 Days)	90/60	104	100	16	13.97	Wound gaping
9	Peritonitis (1 Day)	100/70	100	150	14	1226	Nil
10	Intestinal Obstruction(2days)	90/60	104	100	15	11.81	Nil
11	SAIO (2days)	96/60	98	75	14	12.46	Nil
12	Peritonitis (2 Day)	106/70	96	150	15	13.83	Nil
13	Peritonitis (1 Day)	104/80	92	200	14	12.46	Nil
14	SAIO (2days)	80/60	104	50	17	13.81	Nil
15	Peritonitis (2 Day)	110/60	92	200	14	12.89	Wound gaping
16	Peritonitis (1 Day)	90/60	96	75	15	13.83	Nil
17	SAIO (2days)	106/80	100	175	16	12.84	Nil
18	Peritonitis (2 Day)	96/70	110	100	16	14.23	Wound gaping

Table 2: Pulse Rate vs IAP Grade

Pulse Rate Range	Grade 1	Grade 2	Grade 3	Grade 4
0-20	0	0	0	0
20-40	0	0	0	0
40-60	0	0	0	0
60-80	0	0	0	0
80-100	13	5	0	0
100-120	5	8	4	0
120-140	0	0	3	2
Total number of patients attended in each Grade	18	13	7	2

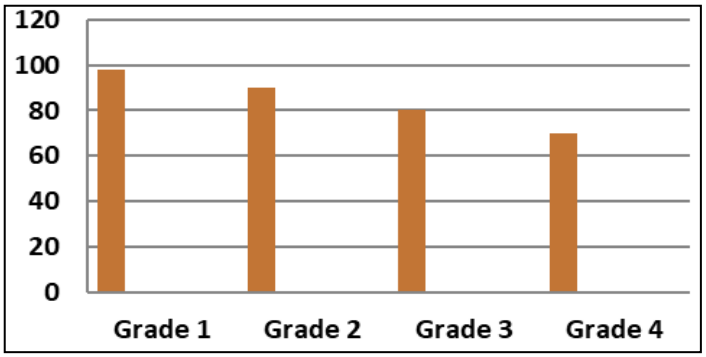

Fig 2: Pulse rate vs IAP grade

Table 3: Mean Systolic B.P. vs IAP Grade

Systolic B.P. Range	Grade 1	Grade 2	Grade 3	Grade 4
0-10	0	0	0	0
10-20	0	0	0	0
20-30	0	0	0	0
30-40	0	0	0	0
40-50	0	0	0	0
50-60	0	0	0	0
60-70	0	0	0	0
70-80	0	0	1	2
80-90	8	3	5	0
90-100	2	8	1	0
100-110	8	2	0	0
Total number of patients attended in each Grade	18	13	7	2

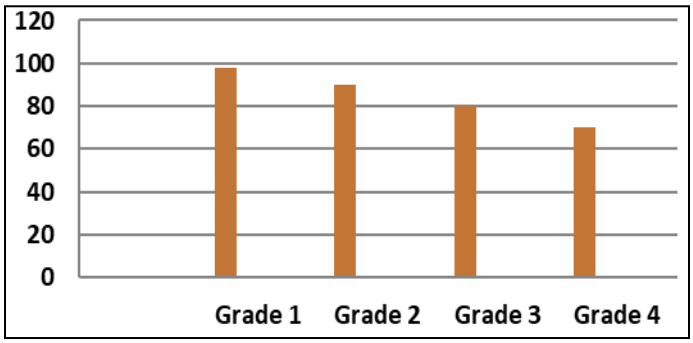

Fig 3: Mean Systolic B.P. vs IAP grade

Analysis of grade 2

1. Out of a total number of 40 patients 13 patients belonged to this category which is 32%.
2. 4 patients were diagnosed with two-day history of peritonitis, 4 patients with three-day history of peritonitis, 2 patients with two-day history of intestinal obstruction (including 1 case of sigmoid volvulus) 2 patients with hemoperitoneum and 1 patient with three-day history of intestinal obstruction.
3. The average pulse rate was 102/mt, the average systolic blood pressure 90mmhg and the average respiratory rate 16/mt. Figure 2 and 3
4. 1 patient with a 3-day history of peritonitis having the higest IAP (23.45 mm hg) in this subset of patients expired on the 3rd post-operative day as in Table 4.

Table 2: Analysis of Results

No.	Dignosis	BP	P.R.	U.O.	R.R.	IAP (mmHG)	Post Op. Complications
1	Peritonitis (3 Days)	90/50	92	100	18	20.58	Wound gaping
2	Hemoperitoneum (1 day)	80/60	110	50	17	24.26	Nil
3	Peritonitis (2 Days)	90/60	110	50	15	16.91	Nil
4	Hemoperitoneum (1 Day)	80/50	120	50	16	23.58	Nil
5	Peritonitis (2 Days)	100/60	110	150	18	15.44	Nil
6	Peritonitis (2 Days)	90/60	110	100	17	17.47	Nil
7	Peritonitis (3 Days)	110/70	88	150	19	20.50	Wound gaping
8	Peritonitis (3 Days)	90/50	116	50	16	23.45	Expired (2nd pod)
9	Intestinal obstruction (3 days)	90/60	96	100	18	20.20	Nil
10	Intestinal obbbstruction-sigmoid volvulus (3 days)	80 SBP	104	50	15	22.58	Nil
11	Peritonitis (3 Days)	90/50	110	75	16	23.45	Nil
12	Intestinal obstruction (2 days)	96/70	100	50	16	22.23	Nil
13	Peritonitis (2 Days)	90/60	96	100	18	20.20	Nil

Analysis of grade 3

1. Out of a total number of 40 patients 7 belonged to this category which is 18%.
2. 2 patients were diagnosed with four-day history of patinoitis, 2 patients with sigmoid volvulus and 3 patients with hemoperitoneum
3. The average pulse rate as 120/mt the average systolic blood pressure 80 mmhg and the average respiratory rate 17/mt. Figure 2 and 3
4. 1 patient developed burest abdomen (ip.no:34847, case of 4 day old peritonitis) and 1 patient expired on the 1st post-operative day (ip.no:05255, case of 4 day old peritonitis).
5. Urine output in these patients was low and 1 patient presented with anuria. as in Table 4

Table 3: Analysis of Results

No.	Diagnosis	BP	P.R.	U.O.	R.R.	IAP (mm HG)	Post Op. Complications
1	Hemoperitoneum (1 day)	80/50	116	125	19	26.49	Nil
2	Peritonitis (4 days)	80 SBP	110	Nil	18	29.30	Burst abdomen
3	Sigmoid Volvulus (2 days)	84 SBP	120	50	17	30.88	Nil
4	Peritonitis (4 days)	70 SBP	126	25	20	34.13	Expired
5	Hemoperitoneum (1 days)	80 SBP	124	100	18	26.47	Nil
6	Sigmoid Volvulus (3 days)	90/60	120	100	20	28.67	Nil
7	Hemoperitoneum (1 days)	80 SBP	126	50	17	25.73	Nil

Analysis of grade 4

1. Out of a total number of 40 patients 2 patients belonged to this category which is 5%.
2. 2 patients with a history of 4-day peritonitis were present in the subset.
3. The average pulse rate was 127/mt, the average systolic blood pressure 70mmhg and the average respiratory rate 25/mt.
4. Both the patients had anuria and succumbed to death within 3-4 hours of presentation to the emergency as in Table 4

Table 4: Analysis of Results

No.	Dignosis	BP	P.R.	U.O.	R.R.	IAP(mmHG)	Post Op. Complications
1	Peritonitis (4 Days)	70 SBP	130	Nil	24	36.76	Expired (before surgery)
2	Peritonitis (4 Days)	70 SBP	125	Nil	26	38.45	Expired (before surgery)

Discussion

A total number of 40 patients were assessed in the study and the changes in various clinical parameters were correlated with changes in the Intra-Abdominal Pressure. The intra-abdominal pressure grading system used in this study is as recommended by burch and moore *et al*.

This study demonstrates that increase in Intra-abdominal pressure has its physiological effects like fall in blood pressure, rise in the pulse rate, increased respiratory rate, and decrease in urine output [3, 6, 13, 14, 15].

Intra-abdominal hypertension, also known as Abdominal Compartment Syndrome (ACS) is a common and life-threatening complication which occurs after surgery for major abdominal trauma. In the post-operative period an intra-abdominal pressure of 3-15 mm Hg is considered normal [7].

Similarly, Diabel *et al*. found that while the mesenteric and intestinal mucosal blood flow reduction occurs at a IAP of 20mm of Hg, hepatic and portal flow become compromised at a IAP of 10mm of Hg [8].

Increased IAP results in a decrease in mesenteric blood flow to 63% of base line despite marinating normal mean arterial blood pressure [9].

The elevated IAP increases the intra cranial pressure and reduces the cerebral perfusion pressure secondary to elevated intra thoracic pressure and elevated central venous pressure with impaired cerebral venous outflow [10].

Pickhardt PJ *et al*. got, CT Scan findings [11] extrinsic compressions of inferior vena cava by retroperitoneal haemorrhage or exudates, direct renal compression, bowl wall thickening etc.

In this series 4 patients died, none with Grade 1 IAP, one with Grade 2, and one with Grade 3 and two with Grade 4 IAP.

Out of 40 patients, 18 (45%) had Grade 1 intra-abdominal pressure. Patients in this group presented with short duration of symptoms and were clinically stable all through.

Patients with Grade 3 and severe form of Grade 2 Intra-abdominal pressure at clinical delay on resuscitating these patients results in acute renal failure [6, 15].

Those patients with less severe form of Grade 2 (IAP between 16 to 20 mmHg) behaved like Grand 1 and those with severe form of Grade 2 (IAP between 21 to 25 mmHg) behaved; like Grade 3.

Patients with hemoperitoneum, sigmoid volvulus mostly belong to Grade 3 category and hence need to be give utmost priority in resuscitation and need to be posted for surgery as early as possible.

In this study done by moore and hargest *et al*. [6]. value above 20 mmHg were considered abnormal in most and a similar observation was as noted by Meldrum *et al*. [17].

Based on the Intra-abdominal Pressure, patients al ridk can be delivered before irreversible organ derangements occur [6, 16].

Although clinical estimation of IAP by abdominal girth or by examiners feel of the tenseness of the abdomen is far from accurate with sensitivity of 40% [18].

Conclusions

This Study demonstrates that increase in Intra-Abdominal Pressure causes a change in different clinical Parameters.

Grade 4 Intr-Abdominal Pressure is associated with Abdominal compartment syndrome and hence with very high mortality.

Measurement of Intra-Abdominal Pressure by the Sedrek's technique is easy, reliable and can underlying physiological status.

Intra-Abdominal Pressure measurement can be used as an independent clinical parameter to assess the patients current clinical condition.

Intra-Abdominal Pressure measurement also helps in prioritizing surgical intervention in emergency.

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