

## **Admission Haematological Abnormalities and Postoperative Outcomes in Neonates with Acute Surgical Conditions in Alexandria, Egypt**

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**Background:** *Haematological parameters in neonates are significantly deranged in the presence of an acute gastro intestinal surgical condition. This study analysed pattern of admission haematological abnormalities and their relation to postoperative outcomes in acute surgical newborns.*

**Methods:** *Conveniently obtained record files of neonates ( $\leq 30$  days of age) who undergone surgery for acute surgical conditions between January 2014 and January 2015 at El Shatby hospital, Alexandria-Egypt were studied. Information collated included patients demographic characteristics and haematological investigations results of blood samples drawn at time of admission.*

**Results:** *A total of 156 neonates with available admission blood investigations results were studied. Low haemoglobin level was present in 3.2% (5) of cases all being peritonitis neonates,  $P=0.01$ . About 39.1% (61) of newborns had raised renal function tests results,  $P=0.01$  and most of them had also abnormal serum electrolytes,  $P=0.03$  and C-reactive protein,  $P=0.00$ . Most of cases with abnormal liver function tests results had hyperbilirubinaemia,  $P=0.04$ , and hypoglycaemia,  $P=0.03$ . Many of newborns with abnormal bleeding indices had raised renal function tests results,  $P=0.03$ . Hyperbilirubinaemia was found in 43.2% (54/125) of cases,  $P=0.00$  and most of them had also hypoglycaemia,  $P=0.00$ . Anaemia was significantly associated with development of postoperative complications= $0.01$ .*

**Conclusion:** *Haematological parameters in neonates are significantly disturbed by acute gastrointestinal surgical conditions. Serum electrolytes, C-reactive protein and bleeding indices are useful indicators of renal function.*

**Keywords:** Haematological abnormalities, neonates, acute gastrointestinal surgical emergencies, outcomes.

### **Introduction**

Disruption of normal gastro intestinal function due to anatomical anomalies, poor or absence of motility/peristalsis, perforation and bowel gangrene significantly affect haematological parameters in acute surgical newborns<sup>1-3</sup>. Some haemorrhage occurring from perforations and gangrenous bowel can cause anaemia in surgical neonates, like in necrotizing enterocolitis where a baby can present with bloody stools<sup>4,5</sup>. Sepsis resulting from peritonitis enhance haemolysis and cause anaemia<sup>6,7</sup>. Elevated white blood cell counts (WBC) and C-reactive protein (CRP) are the indicators of sepsis in newborns<sup>8-10</sup>. Obstruction in the gastrointestinal tract can lead to septicaemia due to secondary over growth of the enteric bacteria with rapidly production of endotoxins weakening the intestinal epithelium and eventually penetrate the bowel wall into the blood stream or causes bowel perforation<sup>11,12</sup>. Bowel distention cause increase in the intraluminal pressure shunting blood away from capillary bed causing decreased mucosal oxygen consumption and capillary venous congestion leading into reduced arterial blood supply, ischaemia, gangrene and perforation with resultant peritonitis. Vomiting or regurgitation in a surgical neonate can lead to aspiration pneumonia<sup>5,11,13</sup>. C- reactive protein

serial measurements are useful in monitoring response to antibiotic treatment in infected newborns<sup>14</sup>. Vomiting in a surgical neonate may cause significant dehydration leading to renal hypoperfusion and failure resulting into raised serum creatinine and blood urea nitrogen<sup>4,15</sup>. Serum electrolytes (sodium, potassium, chloride) are also important markers of renal function, potassium is the most reliable marker of renal failure due to its decreased filtration and secretion in the distal tubules resulting into hyperkalaemia<sup>16</sup>. Disturbance of the normal gut function also affect acid base equilibrium causing hypo or hyperkalaemia depending on the site affected, and loss of sodium and chloride through vomiting and nasogastric tube drainage<sup>1,11</sup>.

Septicaemia resulting from acute surgical conditions like peritonitis due to gut perforation or gangrene damages hepatocytes directly causing elevation of aspartate aminotransferase (AST) and alanine aminotransferase (ALT)<sup>6,17</sup>. Hepatocellular injury due to sepsis also affect a newborn liver coagulation factors synthesis ability indicated by prolonged prothrombin time (PT), and activated partial thromboplastin time (APTT)<sup>17,18</sup>. Hyperbilirubinaemia in neonate with acute gastrointestinal surgical emergency may occur from increased enterohepatic circulation due to stasis of intestinal contents especially in small intestinal obstruction. Sepsis resulting from bacteria translocation or peritonitis enhances haemolysis and cause hepatic cells damage impairing liver bilirubin uptake and excretory ability causing jaundice<sup>6,7,12,17</sup>. Interruption of oral intake due to acute gastro intestinal surgical conditions in neonates may cause hypoglycaemia.

Septicaemia due to bacteria translocation and peritonitis may cause increased metabolic demand and cause hypoglycaemia, hyperglycaemia may occur in some cases, however, it is rare<sup>3,4,19</sup>. Low platelets levels is one of the indicators of neonatal sepsis resulting from acute surgical conditions<sup>20</sup>, also some conditions like necrotizing enterocolitis are associated with haematopoietic disturbances causing thrombocytopaenia with or without disseminated intravascular coagulation<sup>21</sup>. Adequate preoperative haematological evaluation and correction in acute neonatal gastro intestinal surgical conditions is important for proper patient preparation, ensuring safe surgery, and good outcome. This retrospective study aimed to determine the pattern of haematological abnormalities at admission and their relation to postoperative complications and mortality among neonates with acute surgical conditions.

### **Patients and Methods**

A one year retrospective study was conducted at the paediatric surgery department, El Shatby hospital in Alexandria Egypt between February 2014 and January 2015. Only haematological investigations results of blood samples taken at admission from neonates ( $\leq 30$  days of age) who were operated for acute surgical conditions were taken into the study by convenient method. Data collection was done by using a structured form from patient record files. Information collected included age, sex, birth weight, gestational age at birth, associated maternal co morbidities, mode of delivery, duration of symptoms, diagnosis, other associated anomalies, associated medical conditions and haematological investigations results of the blood samples taken at admission which included: haemoglobin level whereby low/abnormal level was regarded as value less than 11.5 g/dl. White blood cells counts, abnormal/raised counts was considered if the value was greater than  $10 \times 10^6/L$ . C-reactive protein, abnormal/raised level was regarded when the value was higher than 0.5mg/dl. Renal function tests included serum creatinine and blood urea nitrogen, abnormal/raised renal function tests was considered if one of these parameters was raised, abnormal/raised serum creatinine level was taken if the value was more than 1.3 mg/dl and for blood urea nitrogen if the level was greater than 18 mg/dl.

Serum electrolytes included serum potassium, sodium and chloride, abnormal serum electrolytes was regarded if at least one of these parameters was higher or lower than the normal range, the normal range for sodium was 136-145 mmol/l, potassium 3.5-5.1 mmol/l and chloride 98-107 mmol/l. Liver function tests entailed Aspartate amino transferase (AST) and Alanine amino transferase (ALT), abnormal liver function tests were considered if one of these enzymes was raised above 37 U/L for aspartate amino transferase and 78 U/L for Alanine amino transferase. Bleeding indices included prothrombin time (PT) and partial thromboplastin time (PTT), if one of these factors was prolonged the results were regarded as abnormal, prolongation beyond 14 seconds was taken as abnormal for prothrombin time and more than 40 seconds for partial thromboplastin time. Serum bilirubin levels was regarded as abnormal if total serum bilirubin was higher than 1.00 mg/ l. Blood glucose level was regarded as abnormal/low if the value was less than 74 mg/dl and Platelets level less than  $100 \times 10^9$  was regarded as abnormal/low. The reference values were according to the set laboratory analyzers ranges. Complete blood count was done by haematological analyzer: Swelab-Alfa X, biochemistry by Siemens Dimension RL Max, and bleeding indices was done manually. Other data collated included post operative complications and outcomes at discharge. Data collected were cleaned and analyzed using the SPSS version 20. Categorical data were analyzed using Fisher's exact and chi-square tests and a P value  $\leq 0.05$  was considered as significant. Permission to carry out this study was obtained from hospital management.

## Results

Haematological investigations results of 156 surgical neonates whose admission blood investigations results were available were studied. Most of the studied newborns were males, 66.0% (103/156), **Table 1**.

Most of babies were aged below 7 days, 57.1% (89/156), the majority had normal birth weight ( $\geq 2.5$  kg birth weight), 84.0% (131/156) and were born at term 87.8% (137/156). Associated maternal conditions during pregnancy occurred in 12.8% (20/156) cases. These included premature rupture of membranes (7), pre-eclampsia (6), anaemia (5), diabetes mellitus (3) and cardiomyopathy (1). Most of cases were delivered by caesarean section 58.9% (92/156) and a half of cases presented late to hospital 50.0% (78/156). Except for serum bilirubin, blood glucose, and C-reactive protein investigations, results were obtained in 125 cases, 42 neonates and in 19 cases respectively. Overall 91.0% (142/156) newborns had abnormal results in at least one of the haematological parameters investigated.

### Haemoglobin level

Only 3.2% (5/156) of babies had low haemoglobin level at admission and all were peritonitis cases,  $P = 0.01$ , and aged above 7 days of life,  $P = 0.00$ . Most of low haemoglobin neonates were females, had normal birth weight ( $\geq 2.5$  Kg birth weight), were term babies ( $\geq 37$  weeks of gestation),  $P \geq 0.11$ , had no associated maternal co morbidities like diabetes mellitus, were delivered by caesarean section and were early presenters,  $P \geq 0.06$ . Majority of babies with low haemoglobin levels had also abnormal white blood cells count levels, renal function tests results, serum electrolytes, serum bilirubin and C-reactive protein levels, and normal bleeding indices, platelets and liver function tests results,  $P \geq 0.06$ .

### White blood cells counts

Raised white blood cells count was found in 35.9% (56/156) of cases, and most of these cases were among oesophageal atresia, intestinal atresia and diaphragmatic hernia cases,  $P = 0.04$ . Most of children with high white blood cells count results were aged below 7 days, were males,

were delivered at term, and had normal birth weight,  $P \geq 0.07$ , also most had no associated maternal co morbidities like premature rupture of membrane and diabetes mellitus, were delivered by caesarean section and were early presenters ( $< 2$  days of symptoms),  $P \geq 0.06$ . Most of cases with abnormal white blood cells counts had abnormal serum glucose, normal renal function tests, serum electrolytes, serum bilirubin, bleeding indices, liver function tests, haemoglobin level, and platelets levels, however, cases were equally distributed in C- reactive protein,  $P \geq 0.32$ .

#### ***C-reactive protein***

Amongst 19 cases with available admission C-reactive protein results 52.6% (10) had raised values,  $P=0.77$ , most of these were among hirschsprung's disease, imperforate anus and peritonitis babies. Most of cases with abnormal C-reactive protein results were aged less than 1 week, had normal birth weight, were males and term neonates,  $P \geq 0.21$ , also most had no associated maternal obstetric conditions like premature rupture of membranes, and were early presenters,  $P \geq 0.65$ , but cases were equally distributed between modes of delivery,  $P=0.05$ . Most of cases with abnormal C- reactive protein levels had abnormal renal function tests,  $P=0.00$  and serum electrolytes levels  $P=1.00$ , however, they had normal haemoglobin levels, white blood cells count, serum bilirubin, bleeding indices results, liver function tests and platelets levels. Cases were equally distributed in blood glucose results,  $P \geq 0.30$ .

#### ***Renal function tests***

Renal function tests results were high in 39.1% (61/156) neonates, mainly among intestinal atresia, oesophageal atresia and peritonitis cases,  $P=0.01$ . Most of children with raised renal function tests results were among babies aged below 7 days,  $P=0.03$ , had normal birth weight, were mature ( $\geq 37$  weeks of gestation), were males,  $P \geq 0.317$ , had no associated maternal co morbid conditions, were delivered by caesarean section, and were late presenters,  $P \geq 0.51$ . Many of cases with abnormal renal function tests results had abnormal serum electrolytes,  $P=0.03$ , C-reactive protein,  $P=0.00$ , serum bilirubin, blood glucose, and platelets levels,  $P \geq 0.33$  and had normal liver function tests results,  $P=0.04$ , bleeding indices,  $P=0.03$ , haemoglobin levels and white blood cells counts,  $P \geq 0.06$ . One child with oesophageal atresia had right renal aplasia and hypoplastic left kidney with abnormal renal function tests results.

#### ***Serum electrolytes***

Serum electrolytes results were abnormal in 53.2% (83/156) of newborns and most of neonates with abnormal serum electrolytes results were present mainly among intestinal atresia and malrotation cases,  $P=0.91$ . Most of cases with abnormal serum electrolytes levels were aged below 1 week, had normal birth weight, were males and were mature,  $P \geq 0.32$ , many of them also had no associated obstetric complications, presented late,  $P \geq 0.19$ , and were delivered vaginally,  $P=0.00$ . Most of babies with abnormal serum electrolytes results had abnormal blood glucose levels,  $P=0.05$ , C- reactive protein,  $P=0.07$ , and normal renal function tests,  $P=0.03$ , serum bilirubin, platelets, liver function tests, haemoglobin levels and white blood cells counts results,  $P \geq 0.32$ .

#### ***Liver function tests***

Raised liver function test results were seen in 11.5% (18/156) of newborns, most of them were among intestinal atresia cases,  $P=0.73$ . Most of neonates with abnormal liver function tests results aged below 7 days, were males, had normal birth weight,  $P \geq 0.11$ , were mature babies,  $P=0.05$ , had no associated maternal co morbidities, were delivered vaginally, and were early presenters,  $P \geq 0.41$ . Also many of those with abnormal liver function tests results had abnormal serum bilirubin,  $P=0.04$ , serum glucose,  $P=0.03$ , renal function tests, serum electrolytes levels  $P \geq 0.07$ , and normal bleeding indices,  $P=0.03$ , haemoglobin levels, white blood cells counts, and platelets,  $P \geq 0.45$ , but they were equally distributed in C- reactive protein results,  $P=1.00$ .

**Table 1.** Distribution of Newborns According to the Diagnosis by Sex

Diagnosis	Sex		Total (%)
	Males (%)	Females (%)	
Oesophageal atresia	15(62.5)	9(37.5)	24(15.4)
Anorectal malformation	17(81.0)	4(19.0)	21(13.5)
Intestinal atresia	9(45.0)	11(55.0)	20(12.8)
Hypertrophic pyloric stenosis	14(87.5)	2(12.5)	16(10.2)
Peritonitis	9(60.0)	6(40.0)	15(9.6)
Hirschsprung's Disease	10(76.9)	3(23.1)	13(8.3)
Intestinal malrotation	5(50.0)	5(50.0)	10(6.4)
Diaphragmatic hernia	5(55.6)	4(44.4)	9(5.8)
Obstructed inguinal hernia	4(100.0)	0(0.0)	4(2.6)
Exomphalos minor	1(25.0)	3(75.0)	4(2.6)
Intestinal web	2(50.0)	2(50.0)	4(2.6)
Gastroschisis	3(100.0)	0(0.0)	3(1.9)
Meconium ileus	2(100.0)	0(0.0)	2(1.3)
Midgut volvulus	1(50.0)	1(50.0)	2(1.3)
Ileal duplication cyst	2(100.0)	0(0.0)	2(1.3)
Intestinal obstruction secondary to primary adhesions	1(50.0)	1(50.0)	2(1.3)
Annular pancreas	2(100.0)	0(0.0)	2(1.3)
Others	1(33.3)	2(66.7)	3(1.9)
<b>Total</b>	<b>103(66.0)</b>	<b>53(34.0)</b>	<b>156(100.0)</b>

Fisher's exact test,  $P=0.08$

\*Others include: intestinal obstruction secondary to Meckle's diverticulum (1), Intestinal obstruction secondary to colonic tumour (1), eventration (1).

### Bleeding indices

Bleeding indices were prolonged in 7.0% (11/156) babies,  $P=0.67$ , most of babies being among intestinal atresia and oesophageal atresia neonates. Most of neonates with abnormal bleeding indices results were aged below 7 days, had normal birth weight, were mature, were males,  $P\geq 0.21$ , had no associated maternal obstetric conditions like preeclampsia,  $P=0.02$ , were delivered by caesarean section,  $P=0.03$ , and were late presenters,  $P=0.21$ . Most of babies with abnormal bleeding indices had normal liver function tests results,  $P=0.00$ , haemoglobin levels, white blood cells counts, platelets and C- reactive protein,  $P\geq 0.20$ , and had abnormal renal function tests,  $P=0.03$ , Serum electrolyte, serum bilirubin and blood glucose levels,  $P\geq 0.28$ .

### Serum bilirubin

Among 125 cases in which serum bilirubin level results were obtained 43.2% (54/125) had high bilirubin levels,  $P=0.00$  and most of them were among intestinal atresia, oesophageal atresia and intestinal malrotation cases. Most of neonates with high serum bilirubin levels were aged below 7 days,  $P=0.05$ , were males, were mature and had normal birth weight,  $P\geq 0.09$ , had no associated maternal co morbidities, were delivered by caesarean section, and were late presenters,  $P\geq 0.43$ . Most children with abnormal serum bilirubin level results had abnormal blood glucose,  $P=0.00$ , renal function tests, serum electrolytes levels,  $P\geq 0.08$  and had normal



liver function tests,  $P=0.04$ , haemoglobin levels, white blood cells counts, bleeding indices, platelets and C- reactive protein,  $P\geq 0.28$ .

### **Blood glucose**

At admission blood glucose test results were obtained in 42 cases and 59.5% (25/42) had abnormal results,  $P=0.08$ . Most of cases were among intestinal atresia, oesophageal atresia and malrotation neonates. Many of newborns with abnormal blood glucose results were females,  $P=0.03$ , aged below 7 days, had normal birth weight, were born at term  $P\geq 0.18$ , had no associated maternal co morbidities, were delivered caesarean section, and were late presenters,  $P\geq 0.07$ . All cases with abnormal blood glucose levels had normal liver function tests,  $P=0.03$ , haemoglobin levels, white blood cells counts, platelets, and renal function tests,  $P\geq 0.32$ , and had abnormal Serum electrolytes levels,  $P=0.05$ , serum bilirubin,  $P=0.00$ , bleeding indices and C- reactive protein,  $P\geq 1.00$ .

### **Platelets**

Low platelets levels was seen in 1.9% (3/156) of cases,  $P=0.62$ , 2 cases among oesophageal atresia and 1 case in intestinal malrotation babies. All 3 cases were aged below 7 days, 2 were males, all 3 had normal birth weight and born at term,  $P\geq 1.00$ . Two cases had no associated maternal obstetric complications, all 3 were delivered by caesarean section, and 2 cases were early presenters,  $P\geq 0.33$ . All 3 neonates had normal haemoglobin levels, white cells counts, and liver function tests,  $P\geq 0.30$ . Two cases had normal serum bilirubin, bleeding indices,  $P\geq 0.12$ , abnormal serum electrolytes levels, and renal function tests,  $P\geq 0.56$ .

Overall postoperative complications occurred frequently in neonates with normal haematological results,  $P=0.72$ . Postoperative complications included wound sepsis, wound dehiscence, leaking or break down of anastomosis and burst abdomen. These occurred in 28 (17.9%) of the 156 cases ( $P=0.02$ ). Postoperative complications were common in babies with low level of haemoglobin, commonly among peritonitis cases ( $P=0.01$ ). They were also common in those with raised white cells counts, raised renal function tests, abnormal serum electrolyte levels, raised serum bilirubin levels, abnormal blood glucose levels, abnormal liver function tests, high C-reactive protein levels, normal bleeding indices and in those with normal platelets levels ( $P\geq 0.32$ ).

Death occurred in 32 cases, giving a mortality rate of 20.5% ( $P=0.20$ ). Death was common among oesophageal atresia and intestinal atresia neonates. Overall all deaths occurred from the group of abnormal admission haematological results ( $P=0.08$ ). Mortality was high in patients who had abnormal renal function test results at admission ( $P=0.03$ ), high serum bilirubin, ( $P=0.02$ ), high bleeding indices ( $P=0.00$ ), low platelets levels, low serum glucose, raised white cells counts, and raised liver function tests ( $P\geq 0.12$ ). Mortality was the same between children with normal and abnormal haemoglobin levels, serum electrolytes, and C-reactive protein levels ( $P\geq 1.00$ ). Multivariate logistic regression analysis of the haematological parameters seen to be highly associated with mortality revealed no statistical significant association: Abnormal renal function tests ( $P=0.06$ , OR 0.42, 95% CI; 0.17-1.04), raised serum bilirubin levels ( $P=0.07$ , OR 0.44, 95% CI; 0.18-1.07) and prolonged bleeding indices ( $P=0.07$ , OR 0.30, 95% CI; 0.08-1.11).

### **Discussion**

Assessment and normalization of haematological parameters enables safe surgery and good outcomes in emergency neonatal surgery<sup>2,22</sup>. In this work majority of cases had at least one deranged laboratory values of blood samples taken at time of admission likewise the findings of others<sup>2,23</sup>. Osifo *et al*<sup>23</sup> in their study found all neonates to have normal haemoglobin levels at

admission, in this study five all being peritonitis cases due to perforations in the stomach and intestines had low haemoglobin levels and this observation was statistically significant illustrating peritonitis probably due to some haemorrhage and resultant septicaemia enhancing red blood cells lysis possibly from large size perforations play big role in causing anaemia in newborns with gut perforation. Other factors reported as risks for developing anaemia in neonates include prematurity and low birth weight<sup>24,25</sup>, associated maternal co morbidities like diabetes mellitus<sup>26</sup>, and late presentation to hospital<sup>3</sup>.

Most cases with anaemia in this study did not have these risk factors; however, this finding was not statistically significant. Age above one week of life and delivery by caesarean section are also the risks for anaemia in neonates<sup>25,27</sup>, in this study all anaemic cases were aged above seven days with this observation being statistically significant and most of them were delivered by caesarean section indicating possibly these to be contributing factors to anaemia. Most of anaemic cases in this study had septicaemia and acute renal failure demonstrating these to be among the important factors for developing anaemia in this study as they increase rate of physiological decline of haemoglobin concentration after birth by increasing red blood cells lysis and reduce erythropoietin production respectively. However this observation was not statistically significant in this study.

Finding of raised white cell counts in neonates with acute surgical conditions prior surgery is common due to aspiration pneumonia, bacteria trans location into blood stream, and spread of bacteria into peritoneum from gut perforations causing septicaemia<sup>12,23</sup>. Septicaemia was higher in this study compared to that reported in a survey done by Kataria *et al*<sup>8</sup> probably due to high number of peritonitis cases and late presenters in this study. The observation of high septicaemia in this analysis was statistically significant. The known risk factors for neonatal septicaemia include prematurity and low birth weight, premature rupture of membrane for more than 24 hours<sup>10,28</sup>, maternal diabetes mellitus<sup>26</sup>, vaginal delivery<sup>27</sup> and late presentation<sup>5</sup>. These factors were not present in most of septicaemic cases, indicating them to have little role in the development of septicaemia in neonates in this study. But this observation was statistically insignificant. Most cases with septicaemia had hypoglycaemia depicting septicaemia to have a big impact on blood glucose levels. However, this finding did not show statistical significance.

Raised blood C-reactive protein is another indicator of septicaemia in neonates. Together with white blood cell counts they have been used in the diagnosis of neonatal septicaemia<sup>9, 10, 14</sup>. In this study a small sample of C-reactive protein results were obtained from which most were raised. Low birth weight, prematurity, premature rupture of membranes for more than 24 hours, vaginal delivery and late presentation to hospital are the reported risks for raised C reactive protein in neonates<sup>5,14,29</sup>, but they were not observed in most of cases with abnormal C-reactive protein in this study showing their small role for raised C reactive protein among cases in this analysis. Nevertheless this observation was not statistically significant. Majority of cases with raised C- reactive protein had acute renal failure and this observation was statistically significant demonstrating C- reactive protein to be also a marker of renal failure as previous reported<sup>30</sup>.

Acute renal failure can occur in a neonate with an acute gastrointestinal surgical condition due to significant dehydration from continuous secretory fluid loss and inability to swallow any fluid into stomach like in case of oesophageal atresia, severe vomiting and loss of fluid through nasogastric tube and through gut perforations into peritoneal cavity causing reduced renal perfusion. Acute renal failure is characterized by raised serum creatinine and blood urea nitrogen<sup>4, 15</sup>. In this analysis more than one third of babies had acute renal failure and this observation was statistically significant. However, Osifo *et al*<sup>23</sup> found more than a half of cases

to have acute renal failure probably due to large number of delayed cases and inadequate fluid administration in the initial centers and during transport to referral centers. Low birth weight prematurity and late presentation are the risk factors for raised renal function tests results in sick neonates<sup>15,22,23</sup>, however, in this analysis only late presentation was present in most of babies with deranged renal function illustrating it to be important factor for deranged renal function in acute surgical neonates. Most of the newborns with abnormal renal function tests results had also abnormal serum electrolyte and C –reactive protein with these observations being statistically significant stressing these also to be markers of renal failure<sup>16,30</sup>. Liver function tests were significantly normal among neonates with acute renal failure implying acute renal failure not to adversely affect liver function.

Finding abnormal serum electrolytes levels in a neonate with acute surgical condition is common due to vomiting or oral pharyngeal secretory fluid loss<sup>1,11</sup>. More than a half of babies had abnormal serum electrolytes in the current survey, similar results were obtained by Osifo J *et al*<sup>23</sup> illustrating electrolyte derangement to be very common among acute surgical neonates and also stressing the importance of appropriate intravenous fluid administration and balance in newborns requiring emergency surgery. Vaginal delivery, late presentation, prematurity and low birth weight are the known risks for serum electrolytes derangement in neonates<sup>22,23,31</sup>. In this analysis vaginal delivery was significantly associated with abnormal serum electrolyte levels in neonates probably due to stress from labour processes leading into elevated anti diuretic hormones causing increased fluid retention by kidneys resulting into hyponatraemia<sup>31</sup>. Also delayed presentation was common among neonates with abnormal serum electrolyte levels signifying late presentation with in adequate intravenous fluid administration to be a risk for derangement in serum electrolytes the same as it was explained by others<sup>13,23</sup>. Many babies with abnormal serum electrolyte levels had hypoglycaemia and this observation was statistically significant probably due to delayed presentation and inappropriate fluid balance prior admission also contributed to hypoglycaemia as well. Most of babies with deranged serum electrolyte levels had normal renal function tests results and this finding was statistically significant demonstrating not all serum electrolytes to be the markers of renal failure. Potassium, "hyperkalaemia", is the most reliable electrolyte marker of renal failure<sup>16</sup>.

Raised liver function tests results were seen in almost one eighth of neonates in this survey. It had been reported prematurity and low birth weight to be risks for abnormal liver function tests results in newborns<sup>17,22</sup>. This is in contrast to the findings in this study whereby most of deranged liver function tests occurred among term babies and this observation was statistically significant. Most of cases with abnormal liver function tests had also hyperbilirubinaemia probably due to disturbed liver bilirubin uptake from blood. This observation was statistically significant. Also many of the newborns with abnormal liver function tests had hypoglycaemia with this finding being statistically significant proving occurrence of reduced release of liver store of glycogen if the liver is stressed in neonates. Bleeding indices are among the most reliable indicators of liver function status<sup>17</sup>, in this study most cases with abnormal liver function tests results had normal bleeding indices values and this observation was statistically significant possibly illustrating the injury to hepatocytes in these cases was generally mild.

Prolonged bleeding indices were noted in 7.0% of babies mainly the upper gastro intestinal obstruction conditions. Associated maternal obstetric conditions like preeclampsia, low birth weight and prematurity had been documented as risks for coagulation disorder in neonates<sup>17,18,32</sup>, the significance of these factors has not been observed in this study. However delivery by caesarean section has been statistically significantly associated with prolonged bleeding indices in this analysis possibly due to the effect of anaesthetic drugs. Most of neonates with prolonged bleeding indices had renal failure and this finding was statistically significant depicting renal failure to affect coagulation profile in neonates as similarly observed by Holda *et*



*al*<sup>33</sup>. Also many of cases with prolonged bleeding indices had normal liver function tests and this observation was statistically significant indicating coagulation disorder among these cases to be possibly due to factors other than the liver like the effect of renal failure and caesarean section anaesthetic drugs.

In this study more than a third of babies had hyperbilirubinaemia mostly among cases with high gastro intestinal obstruction and this observation was statistically significant probably demonstrating the presence of increased enterohepatic circulation in high intestinal obstruction affecting serum bilirubin levels<sup>6</sup>. Associated maternal obstetric complications like preeclampsia, gestational diabetes mellitus and premature rupture of membranes , also vaginal delivery, low birth weight and prematurity had been reported as risk factors for developing hyperbilirubinaemia in neonates<sup>6,7,32,34</sup>, however in this survey these factors were found to have no significant contribution to development of jaundice. Most of neonates with hyperbilirubinaemia had hypoglycaemia and this finding was statistically significant probably due to increased liver glucose consumption in attempt to cope with elevated bilirubin levels. Also most of babies with hyperbilirubinaemia had normal liver function tests and this observation was statistically significant depicting elevated serum bilirubin to be possibly due to physiologic haemolysis exceeding serum bilirubin liver uptake rate.

Hypoglycaemia occurs among neonates with acute surgical gastro intestinal conditions due lack or reduced oral fluid intake such as breast milk, inappropriate and in adequate intravenous fluid administration at the initial centers or due to infection<sup>3,4</sup>. More than a half of cases in which blood glucose results were obtained had hypoglycaemia; nevertheless, this observation was statistically insignificant. Maternal gestational diabetes mellitus, preeclampsia, low birth weight and prematurity and sepsis are among the known risks for neonatal hypoglycaemia<sup>35,36</sup>, but in the current analysis these were not found to be influencing factors for development of hypoglycaemia. Delivery by caesarean section and late presentation are also the risk factors for hypoglycaemia in neonates<sup>3,37</sup> which concurred with the findings in this study , however, this observation was not statistically significant . Most neonates with hypoglycaemia had normal liver function tests results and this observation was statistically significant illustrating hypoglycaemia to have no adverse effect on liver cells.

A low platelets level is one of the indicators of sepsis in neonates<sup>20,29</sup>, and commonly occurs among necrotizing enterocolitis cases<sup>21</sup>. Only 3 cases in this study had thrombocytopaenia. Preeclampsia, gestational diabetes mellitus, premature rupture of membrane, low birth weight and prematurity and septicaemia are the known risks for thrombocytopaenia in neonates<sup>20,26,29,38</sup>, but they did not have major contribution in thrombocytopaenia development in this survey.

Only anaemia was found to be significantly associated with development of postoperative complications indicating anaemia to have a great impact on wound outcome post operatively. It may also be due to all cases having anaemia had peritonitis which is highly associated with post operative wound complications as also explained by Ansari *et al*<sup>39</sup>. By cross tabulation significantly mortality was high among neonates with renal failure, hyperbilirubinaemia and prolonged bleeding indices which is one of the reliable marker of liver function, synthetic ability<sup>17</sup>, however the significance was not demonstrated by multivariate analysis as similarly observed by Manchanda *et al*<sup>2</sup> indicating possibly high mortality is due to the nature of surgical condition as these haematological abnormalities were seen mainly among oesophageal atresia and intestinal atresia cases which are the most serious acute surgical conditions in neonates

## Conclusion

In conclusion, neonatal haematological parameters are significantly affected by acute surgical conditions. Abnormal serum electrolytes and C-reactive protein levels are the indicators of renal failure. Abnormal serum electrolytes levels are associated with hypoglycaemia. Impaired liver function reduce bilirubin uptake from blood and release of glycogen into blood. Anaesthetic drugs given during caesarean section may have effect on neonatal coagulation factors. Hyperbilirubinaemia increases glucose consumption by the liver. Anaemia contributes greatly to development postoperative wound complications.

## Recommendations

It is therefore recommended that adequate resuscitation, assessment and stabilization of haematological parameters preoperatively are essential for reduction of morbidity and mortality in acute surgical neonatal conditions. Also serum electrolytes and C-reactive protein levels may be used as renal function tests in places with lack of laboratories facilities for measuring serum creatinine and blood urea levels.

## Study limitations

This is a retrospective study therefore other maternal and neonatal factors that may affect haematological profile of a neonate like maternal rhesus factor, A,B,O blood groups, maternal fever, drugs and nutrition status, events of labour and type of gestation etc, could not be studied. Also for some haematological parameters we could not get results in all cases.

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