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Original Article

Causes and results of non-cardiac surgeries in newborns admitted to the NICU

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Abstract

Background and aims: Surgery is an important and life-saving health service that can treat many of the congenital anomalies. This study aimed to investigate the possible causes and outcomes of non-cardiac surgeries in newborns admitted to the neonatal invasive care unit (NICU) department of Be'sat Hospital in Hamadan during the period 2011 to 2017.

Methods: This study included all neonates (482 newborns) who were admitted to the NICU department of Be'sat hospital during the period 2011-2017 due to non-cardiac surgery, and had hospital records. The required information was extracted from their hospital records and the surgical outcomes and complications were analyzed with respect to other variables such as the gender, type of delivery, gestational age, birth weight, and disease.

Results: According to our study results, 80.5% of the newborns had the gastrointestinal disease which was the most common cause of surgery found in this study. Moreover, imperforated anus (20.8%) and esophageal atresia (17.1%) were among the most common disorders. Esophageal atresia (33.9%) was detected to be the most common disease among the newborns who died during the course of the study. The results from the study showed that the outcome of surgery had statistically significant relationship with gender ($P=0.011$), type of breastfeeding/feeding ($P<0.001$), gestational age ($P<0.001$), and birth weight ($P<0.001$).

Conclusion: Fetal examinations during pregnancy and neonatal care immediately after birth were recommended for early diagnosis of esophageal atresia, diaphragmatic hernia, and imperforated anus. Since gender (male), breastfeeding, normal gestational age, and normal birth weight had a significantly positive effect on surgery outcome, higher quality care was also recommended for infants lacking these characteristics.

Keywords: Newborn, Surgery, Non-cardiac surgery, Congenital disorder, NICU

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Introduction

Neonatal Mortality Rate is one of the most important health indexes, which also has a direct effect on infant mortality rates and children less than 5 years (1). Different causes of neonates' death have been identified in different countries depending on the socio-economic situations of the countries (2). In 2015, it was estimated that 303 000 out of more than 2 million neonates died from *congenital anomalies* in the world (3). Congenital anomalies – also known as *congenital disorders*, *congenital malformations*, or *birth defects* – refer to the groups of structure, function, or metabolism abnormalities that cause physical or mental disabilities in newborns. Many of these congenital anomalies can be treated or improved with cost-effective and safe methods that improve long-term outcomes (4-6). Surgery is an important and life-saving health service that can treat many of these congenital anomalies (7,8).

In a study by Eghbalian and Ghorbanpour, around three percent of the neonates had at least one major physical abnormality that required surgical intervention. Esophageal atresia, intestinal obstruction, and imperforate anus were the most common neonatal abnormalities that required surgery (9-11). After the surgery, neonates are almost always admitted to the neonatal invasive care unit (NICU), which increases the chance of recovery, reduces the risk of death after surgery, and leads to a significant improvement in the final prognosis of surgery (12-14). Plenty of studies have examined the possible relationships among risk factors (e.g., maternal illness, age, gender, and the socio-economic situation of family) and surgery's outcomes (9,10,15). However, various types of surgeries leading to hospitalization and the surgeries' causes, results, and complications have received little or no academic attention so far. This study, therefore, aimed to investigate the causes and outcomes of non-cardiac surgeries in newborns admitted to the NICU department of Be'sat hospital in Hamadan during a period from 2011 to 2017. It was hoped that our study results – if confirmed, would provide policy-makers with a proper platform for formulating effective policies in the field of neonatal health in order to minimize the financial and human burden of the given disability. It should be noted that this study was limited to non-cardiac surgeries since there was no cardiac surgery unit for neonates in Hamadan, and the

neonates were referred to other hospitals in larger cities like the capital, Tehran.

Materials and Methods

This study included all neonates (482 newborns) who had been admitted to the NICU department of Be'sat hospital during the period 2011-2017 due to non-cardiac surgery, and had had hospital records. The required information including gender, age, birth rank in the family, birth weight, gestational age, place of living (city or countryside), parental relationship, maternal age, paternal age, type of delivery, type of feeding, maternal illness during pregnancy, diagnosis, surgical outcome, and complications was extracted from their hospital records. Follow-ups and evaluation of complications of surgeries were limited to the time of hospitalization and were based on the available information in their medical records.

Four subjects out of 482 ones were excluded from this study since their hospital records were not available due to their referral to forensic medicine.

The collected data were analyzed by SPSS 24 using chi-square and *t* tests. The significance level of the tests was set to 5%; in other words, a *P* value less than 0.05 was considered as significant.

Results

In this study, 478 neonates (60.5% boys, 38.9% girls, and 0.6% ambiguous) were assessed. Tables 1 and 2 show a comparison of clinical characteristics and demographic variables for neonates. Since the data recorded for all neonates (including infants whose files were not complete) were considered, the total frequency percentage for all variable levels within each variable was not higher than 100%.

From among all mothers, 305 ones (63.8%) had no disease, 11 had gestational diabetes (2.3%), 10 had hypothyroidism (2.1%), 7 had diabetes mellitus (1.5%), and 20 (4%) had other diseases such as hypertension, gestational hypertension, epilepsy, mental illness, asthma, addiction, toxoplasmosis, inflammatory bowel disease, urinary tract infection, and preeclampsia. No record of maternal illness was found for 125 cases (26.2%) during pregnancy.

Out of 478 infants, 385 ones (80.5%) had gastrointestinal problems, 42 (8.8%) had nervous system problems, 22 (4.6%) had musculoskeletal problems, 21 (4.4%) had urogenital problems, 6 (1.3%) had respiratory problems, and 2 (0.4%) had tumors (Table 3). Totally, 445 neonates (93.1%) had congenital disease and 33 ones (6.9%) had acquired disease. As for acquired diseases, Necrotizing Enterocolitis (NEC) and abscesses were the most common diseases.

Type of surgeries and complications are presented in Table 4. Note that due to the low frequency of many items, they were aggregated into one single variable (called "Other") in order to prevent having sparse groups of the samples. Moreover, multiple complications were observed in some children and, therefore, the total frequency at the level of complication was more than 478 (i.e., more than 100%).

Out of 478 neonates, 422 ones (88.3%) had been discharged after surgery whereas 164 cases (34.3%) had continued their medication for at least two months. Among 56 neonates (11.7%) who had died before the discharge, 19 neonates (33.9%) had esophageal atresia, 11 ones (19.6%) had a diaphragmatic hernia, and four neonates died from Esophageal atresia. Moreover, three subjects were found with gastroschisis, three with necrotizing enterocolitis, and three with tracheoesophageal fistula, each forming 5.4% of the population.

Since more than 80% of the infants had gastrointestinal disorders and, therefore, most of the surgeries were gastrointestinal, variables regarding neonates with gastrointestinal and non-gastrointestinal surgeries were compared in order to avoid data scattering. The results from chi-square test showed no statistically significant relationship between the variables in two groups (Table 5).

The results from the chi-square/independent *t*-test examining the relationship between variables and surgical outcome in dead and discharged neonates (Table 6) showed that there were strong statistical relationships among gender ($P=0.011$), type of feeding ($P<0.001$), gestational age ($P<0.001$) and birth weight ($P<0.001$). Therefore, it seemed that male gender, breastfeeding, term gestational age, and normal birth weight had significantly positive effects on surgery outcome. However, no

Table 1. Neonatal demographic variables

Variable	Mean ± SD	Min	max
Age at the time of hospitalization (days)	4.79±6.832*	1	28
Birth weight (grams)	2845.22±617.558	865	4999
Maternal age (years)	29.02±6.746	15	44
Paternal age (years)	33.8±6.342	21	60

* The ages of the neonates, starting from day 1 up to day 28, formed a heavily one-sided distribution and skewed to the right, which was far from a normal distribution. As a result, the standard deviation of this data was larger than its mean.

Table 2. Comparison of clinical characteristics in neonates

Variable		No. (%)
Birth rank in the family	First child	173 (36.2)
	Second child	135 (28.2)
	Third and more	81 (16.9)
Type of delivery	NVD	194 (40.6)
	C/S	277 (57.9)
Type of feeding	Dried milk	5 (1)
	Breastfed	416 (87)
	NPO	56 (11.7)
Parental relationship	Yes	91 (19)
	No	195 (40.8)
Place of living	City	271 (56.7)
	Countryside	204 (42.7)
Gestational age	Term	351 (73.4)
	Preterm	109 (22.8)
	Post term	2 (0.4)

Table 3. Information on neonatal diseases

Diseases		No. (%)
Gastrointestinal	Imperforate anus	80 (16.7)
	Esophageal atresia	66 (13.8)
	Hirschsprung	38 (7.9)
	Diaphragmatic hernia	30 (6.3)
	Omphalocele	29 (6.1)
	Duodenal atresia	29 (6.1)
	Jejunal atresia	23 (4.9)
	Inguinal hernia	18 (3.7)
	Midgut malrotation	15 (3.1)
	NEC	10 (2.1)
	HPS	10 (2.1)
	Meconium cyst	9 (1.8)
	Gastroschisis	7 (1.5)
	TEF	7 (1.5)
	Other (volvulus, peritonitis, perianal abscess, abdominal cyst, umbilical hernia, Pierre robin syndrome, cholecystitis atresia, anal polyps)	14 (2.9)
Nervous system	Spina bifida, meningocele and meningomyelocele	24 (5.0)
	Hydrocephalus	15 (3.2)
	Subdural and subgaleal hemorrhage	3 (0.6)
Musculoskeletal system	Abscess (breast and limbs)	6 (1.3)
	Septic arthritis	4 (0.8)
	Clubfoot	4 (0.8)
	Cellulitis	3 (0.6)
	Other (limb fractures, polydactyly, osteomyelitis and amniotic band)	5 (1.1)
Urogenital system	Hydronephrosis	11 (2.4)
	Vaginal atresia	3 (0.6)
	Bladder exstrophy	3 (0.6)
	Other (torsion, hypospadias, polycystic kidney)	4 (0.8)
Respiratory tract	lung cysts	5 (1.1)
	Choanal atresia	1 (0.2)
Tumors	Neuroblastoma and sacrococcygeal teratoma	2 (0.4)
	Total (%)	478 (100)

HPS, hypertrophic pyloric stenosis; TEF, tracheoesophageal fistula; NEC , necrotizing enterocolitis

statistically significant difference was observed in other variables from two groups.

Discussion

In the study by Eghbalian and Ghorbanpour, the most common diseases leading to surgeries were determined to be Hirschsprung (19%), imperforate anus (16.7%), esophageal atresia (15%), and inguinal hernia (9.5%) (9). In another study by Abdul-Mumin et al, it was reported that 302 neonates had surgery due to congenital anomalies among which the omphalocele (13.8%), imperforate anus (9.8%), intestinal obstruction (8.4%), spina bifida (7.5%), and hydrocephalus (5.5%) were the most common abnormalities (10).

In our study, 80.5% of neonates had gastrointestinal disorders which were the most common causes for neonatal surgery. Moreover, imperforate anus (20.8%), esophageal atresia (17.1%), Hirschsprung (9.9%), omphalocele (7.5%), duodenal atresia (7.5%), jejunal atresia (6%) and inguinal hernia (4.7%) were discovered to be the most frequent disorders leading to surgery, which was inconsistent with the results from the studies by Eghbalian and Ghorbanpour (9) and Abdul-Mumin et al (10). These contradictory results could be attributed to the difference in size and time frame of the studies. This was confirmed by results from another study where control and case groups were included to identify and reduce the confounding variables.

In the study by Eghbalian and Ghorbanpour, the most common complication after surgery was detected to be electrolyte disorders which required medical therapy after discharge (9).

In our study, clinical symptoms persisted for 1.9% of neonates, pneumothorax occurred for 1.5% of them, and electrolyte disorders afflicted 6 infants (1.3%); this difference could be explained by differences in samples size and duration of the study since our study had a longer time frame and a larger sample size. The overall mortality rate in our study was 11.7% (56 neonates), which may have been underestimated due to the short follow-up

Table 4. Information on features of surgery

Variable		No. (%)
Type of surgery	Colectomy	111 (23.2)
	Reconstructive	107 (22.4)
	Antrectomy and Resectomy/Resection	88 (18.4)
	Esophagostomy	60 (12.6)
	Incision and drainage and puncture	16 (3.3)
	Ladd	10 (2.1)
	Nephrostomy	9 (1.9)
	Pyloromyotomy	9 (1.9)
	Other (Debridement, laparotomy, amputation, shunting, biopsy, vesicostomy, plastic surgeries)	68 (14.2)
Complication	No complication were seen	432 (88.3)
	Reoperation	35 (7.3)
	Clinical symptoms persistence	9 (1.9)
	Pneumothorax	7 (1.5)
	Electrolyte disorders	6 (1.3)

Table 5. Comparison of clinical characteristics in neonates with gastrointestinal and non-gastrointestinal surgeries

Variables		Frequency (%) in neonates with gastrointestinal surgeries	Frequency (%) in neonates with non-gastrointestinal surgeries	*P* value
Gender	Boy	232 (60.3)	57 (61.3)	0.806
	Girl	151 (39.2)	35 (37.6)	
	Ambiguous	2 (0.5)	1 (1.1)	
Birth rank in the family	First child	144 (45.3)	29 (40.8)	0.377
	Second child	110 (34.6)	25 (35.2)	
	Third and more	64 (20.1)	17 (23)	
Place of living	City	220 (57.1)	51 (54.8)	0.782
	Countryside	163(42.3)	41 (44.1)	
Parental relationship	Yes	79 (33.8)	12 (23.1)	0.135
	No	155(66.2)	40 (76.9)	
Type of delivery	NVD	156 (41.1)	38 (41.8)	0.906
	C/S	224 (58.9)	53 (58.2)	
Maternal illness	Yes	38 (13.7)	10 (13.3)	0.940
	No	240 (86.3)	65 (86.7)	
Gestational age	Term	279 (74.4)	72 (82.8)	0.229
	Preterm	94 (25.1)	15 (17.2)	
	Post term	2 (0.5)	0 (0)	
Age at the time of the hospitalization (day)		4.21±6.398	7.19±7.994	0.568
BW (g)		2805± 611.126	3014.10±619.598	0.721
Maternal age (y)		28.75±6.960	30.20±5.675	0.194
Paternal age (y)		33.63±6.229	34.59±6.843	0.237

BW, Birth Weight (g)

Table 6. Comparison of clinical characteristics in discharged neonates and dead neonates

Variables		Frequency (%) in discharged neonates	Frequency (%) in dead neonates	*P* value
Gender	Boy	265 (62.8)	24 (42.9)	0.011
	Girl	155 (36.7)	31 (55.4)	
	Ambiguous	2 (0.5)	1 (1.8)	
Birth rank in the family	First child	155 (45.1)	18 (40)	0.748
	Second child	115 (33.4)	20 (44.4)	
	Third and more	74 (21.5)	7 (15.6)	
Place of living	City	241 (57.1)	30 (53.6)	0.699
	Countryside	178(42.2)	26 (46.4)	
Parental relationship	Yes	80 (31.6)	11 (33.3)	0.843
	No	173(68.4)	22 (66.7)	
Type of delivery	NVD	174 (41.8)	20 (36.4)	0.439
	C/S	242 (58.2)	35 (63.6)	
Maternal illness	Yes	44 (14)	4 (10.5)	0.559
	No	271 (86)	34 (89.5)	
Gestational age	Term	328 (80.2)	23 (43.4)	<0.001
	Preterm	79 (19.3)	30 (56.6)	
	Post term	2 (0.5)	0 (0)	
Type of feeding	Dry milk	5 (1.2)	0 (0)	<0.001
	Breast milk	408 (96.9)	8 (14.3)	
	NPO	8 (1.9)	48 (85.7)	
Age at the time of the hospitalization (day)		5±6.980	3.21±5.386	0.733
BW (g)		2916.53±588.321	2318.82±576.326	<0.001
Maternal age (y)		28.98±6.824	29.28±6.168	0.579
Paternal age (y)		33.86±6.340	33.33±6.421	0.325

NVD, natural vaginal delivery; C/S, caesarean section; NPO, nothing per oral; BW, birth weight (g)

time; in fact, the neonates were not tracked after the discharge in this study, and the recorded complications were only limited to the hospitalization time. Hence, it was recommended that another study with longer follow up times be carried out.

The mortality rate reported by Abdul-Mumin et al (10) was 13.5%, which was close to the rate detected in our study. In addition, esophageal atresia with 33.9% (19 neonates), diaphragmatic hernia with 19.6% (11 neonates), and imperforate anus with 7.1% (4 neonates) were the most common diseases among neonates who died during the course of the study. These results were different from those found in Abdul-Mumin and colleagues' study in which two-thirds of the dead neonates (30 patients) had congenital gastrointestinal abnormalities among which the omphalocele with 23.4%, gastroscopy with 14.9%, and imperforate anal with 12.8% were the topmost fatal abnormalities (10).

This difference could be explained by the factors operated in our study, including more proper prenatal care and more frequent use of early detection methods in the community, as well as by the socio-economic differences among the countries where the studies were conducted.

In another study by Abdul-Mumin et al (16), the quality of prenatal care was reported to be associated with a reduction in infant mortality. Seemingly, by improving and increasing the quality and quantity of the given cares leading to an increase in the overall level of infant health, the need for surgeries could be reduced and, therefore, the surgical mortality rates could be lowered.

Conclusion

In this study, it was concluded that esophageal atresia, diaphragmatic hernia, and imperforate anus were among the most frequent diseases resulting in neonates' death. Fetal examinations during pregnancy and neonatal care immediately after birth were recommended for early diagnosis of esophageal atresia, diaphragmatic hernia, and imperforated anus. Since male gender, breastfeeding, normal gestational age, and normal birth weight were found to have a significantly positive effect on the surgery outcome, higher quality care was also recommended for infants lacking these characteristics.

Conflict of Interests

The authors declare that they have no conflict of interests.

Ethical Approval

This study was performed in accordance with the declaration of Helsinki for human rights; and it was approved by the Hamadan University of Medical Science with a code of ethics (IR.UMSHA.REC.1397.626).

Authors' Contributions

FE designed the study. PN collected the data, wrote and revised the manuscript. AP analyzed and interpreted the data. All authors read and approved the final manuscript.

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