Congenital Duodenal Obstruction: National Trends in Management and Outcomes during the Last Quarter of a Century in Norway

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Abstract

Introduction During the last quarter of a century, new surgical techniques in neonates have been introduced, and neonatal intensive care has developed. Few studies have explored the implementation of new techniques and if outcomes in neonates undergoing gastrointestinal surgery have improved in the last decades. Therefore, this study aimed to investigate possible changes in postoperative outcomes and surgical techniques in all neonates operated for congenital duodenal obstruction (CDO) 1995 to 2020 in Norway.

Material and Methods This is a national multicenter retrospective study of all neonates undergoing surgery for CDO in Norway from 1995 to 2020. Results from three periods (1995–2003, 2004–2012, and 2013–2020) were compared. The study was approved by the local data protection officers (2020/13386) and (2020/15125).

Results We included 186 patients: 41 in period 1 (1995–2003), 83 in period 2 (2004–2012), and 62 in period 3 (2013–2020). Seventy (38%) neonates had Down syndrome and 104 (62%) had additional malformations/disorders. Birth weight, gender, frequency of Down syndrome, and other malformations/disorders did not differ between the three periods. We observed an increased rate of prenatal diagnosis throughout the study period ($p < 0.001$). The only change in surgical technique was the increased use of transanastomotic feeding tubes ($p < 0.001$). Length of stay, postoperative complication rate, days with parenteral nutrition, and 30-day mortality rate were stable over time.

Conclusion Perioperative treatment and postoperative outcomes in neonates with CDO have been surprisingly unchanged during the last quarter of a century. Only an increased rate of prenatal diagnosis and more frequent use of transanastomotic feeding tubes were observed.

Keywords

- ERAS
- neonatal surgery
- enhanced recovery after surgery
- congenital duodenal obstruction
- transanastomotic feeding tube

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Introduction

Congenital duodenal obstruction (CDO) is a structural abnormality affecting 0.5 to 1.5 in 10,000 newborns, and the incidence seems to be stable.[1–3] The most common causes of CDO are duodenal web, duodenal atresia, and obstructing annular pancreas. CDO may present as polyhydramnios prenatally and/or bilious/non-bilious vomit postnatally.[1,4] Surgery is the only curative treatment, and in most cases, a duodenoduodenostomy is created through an upper transverse laparotomy within the first few days after birth.

Outcomes after CDO surgery improved from 1951 to 1995; complication and mortality rates declined, and the length of hospital stay (LOS) was reduced.[5] Better surgical techniques and improved neonatal care were suggested as plausible explanations.[5] Since then, further improvements in neonatal gastrointestinal surgery and neonatal intensive care have been implemented.[6] For instance, alternatives to the standard upper transverse laparotomy have evolved. A supraumbilical incision initially presented for pyloromyotomy in 1986 is a feasible and less invasive surgical approach for CDO repair, giving a better cosmetic result.[7–9] The first successful laparoscopic repair of CDO was reported in 2001.[10] The laparoscopic approach for CDO repair is increasingly more used, and recent results are similar to those reported for CDO repair by laparotomy in terms of complication and mortality rates.[11] Enhanced recovery after surgery (ERAS), implying a multimodal approach to reduce complications and LOS, has improved results in adult gastrointestinal surgery for more than 15 years.[12] ERAS has also gained interest in neonatal surgery, and in 2020, the first ERAS guidelines for neonatal gastrointestinal surgery were published.[13] Early enteral feeding and minimally invasive techniques are two essential principles of ERAS. To improve early enteral feeding in neonates with CDO, the placement of transanastomotic feeding tubes (TAFT) was first used in 1973.[14] However, the authors could not show that TAFT improved oral feeding or reduced LOS in neonates getting a TAFT.[14] Since then, several studies have examined the effects of TAFTs, but it is still debated whether TAFT is beneficial for neonates with CDO.[15,16]

The prenatal detection rate of various congenital malformations has increased during the last quarter of a century, mainly due to technological improvements in ultrasound diagnostics and more frequent use of ultrasound during pregnancy.[17] Recent publications report that 60 to 70% of newborns with CDO have a prenatal diagnosis.[1,4] A prenatal diagnosis may ensure a planned delivery in a tertiary center and earlier surgical correction. Whether a prenatal diagnosis improves postoperative outcomes in neonates with CDO is uncertain, and more research is needed.[18–21]

Based on the recent development in prenatal diagnosis, surgical techniques, and perioperative treatment for neonates undergoing gastrointestinal surgery, we hypothesized that neonates with CDO born in the last decade had better outcomes than those born earlier. No previous study has explored changes in management and outcomes in neonates undergoing surgery for CDO during the past 25 years. Therefore, we performed this study where the primary aim was to investigate if complication rate and LOS in neonates treated for CDO changed from 1995 to 2020. The secondary aims were to explore if surgical techniques had changed and if the rate of prenatal diagnosis had increased and affected surgical outcomes.

Materials and Method

This is a national two-center retrospective study of all neonates undergoing surgery for CDO at Oslo University Hospital (Oslo) and St. Olav's University Hospital (Trondheim) between January 1995 and September 2020. Surgical treatment of neonates with congenital anomalies in Norway is centralized in these two tertiary referral centers.

CDO was defined as a total or partial obstruction between the pylorus and the ligament of Treitz due to a process present at birth. Patients were identified by searching for the ICD-10 diagnoses *Q41.0* (congenital duodenal atresia or stenosis) and *Q45.1* (annular pancreas) in the medical record database and manually going through operation logbooks. Patients who did not undergo surgery for CDO due to major comorbidity, or who were undergoing surgery after the neonatal period (first 28 days after birth), and/or patients with unretrievable medical records were excluded.

Two investigators (M.T. and S.G.), who had not been involved in the treatment of the patients, reviewed the medical records. Data were collected from electronic and analog medical records and registered in EpiData Manager (version 4.6.0.2) (Oslo) or Excel (Trondheim). Background information such as demographics, prenatal diagnosis, age at surgery, and year of surgery was registered. The type of CDO was categorized as duodenal web, duodenal atresia, annular pancreas, tumor, or other (Ladd's bands and intrauterine volvulus). Furthermore, we recorded the type of operation, the number of postoperative days with parenteral nutrition (PN) at the two pediatric surgical centers, and postoperative LOS at the two centers. Postoperative complications were registered and graded according to the Clavien-Dindo Classification system (CD),[22] and serious complications were defined as CD grade 3 to 5.

For statistical analyses, SPSS statistics 28 (IBM corp., Armonk, New York) was used. Patients were categorized by the year of operation and divided into three time periods: period 1 (1995–2003), period 2 (2004–2012), and period 3 (2013–2020). Categorical variables are presented as number and percentage of total. Numerical variables are presented as the mean and standard deviation (SD) for normally distributed data and as median and min-max for not normally distributed data. When comparing two groups, parametric tests (Student *t*-test) and non-parametric tests (Mann-Whitney U test) were used as appropriate. Continuous variables in the three groups were compared with parametric (analysis of variance [ANOVA]) and non-parametric (Kruskal–Wallis test) tests as appropriate. The chi-square test was applied for the comparison of all categorical variables. Additionally, variables with significant differences between all three time periods were analyzed with a linear-by-linear

association to explore the trend. Finally, all data have been visually examined in scatter plots and/or linear regression for numerical variables to investigate possible trends not significant in the group analysis.

The study was approved by the local data protection officers at Oslo University Hospital (2020/13386) and St. Olav's University Hospital (2020/15125), respectively.

Results

We identified 216 patients with CDO born between 1995 and 2020, and 186 patients were included in the study (►Fig. 1); 41 in period 1 (1995–2003), 83 in period 2 (2004–2012), and 62 in period 3 (2013–2020). Thirty patients were excluded because their medical records could not be retrieved or did not match the inclusion criteria. Eighty-five (46%) were boys, and the mean weight and gestational age at birth were 2,608 (SD 700) g and 36.3 (SD 2.7) weeks, respectively. Down syndrome was diagnosed in 70 (38%), and 104 (62%) had additional malformations/disorders. The CDO was caused by a duodenal web in 61 (35%), duodenal atresia in 71 (41%), annular pancreas in 40 (23%), tumor in 2 (1%), and other (compression from Ladd's bands and intrauterine volvulus) in 2 (1%). Patient demographics did not differ between the periods, except for higher gestational age at birth and more neonates without additional malformation/disorders in period 1 (►Table 1).

Ninety-nine (53%) neonates had a prenatal diagnosis, and the frequency of neonates with a prenatal diagnosis increased during the study period ($p < 0.001$) (►Fig. 2, ►Table 1). Neonates with a prenatal diagnosis were born earlier, had a higher rate of additional malformations/disorders, had a longer LOS, their age at operation was lower, and their rate of serious complications was higher than neonates without a prenatal diagnosis (►Table 2).

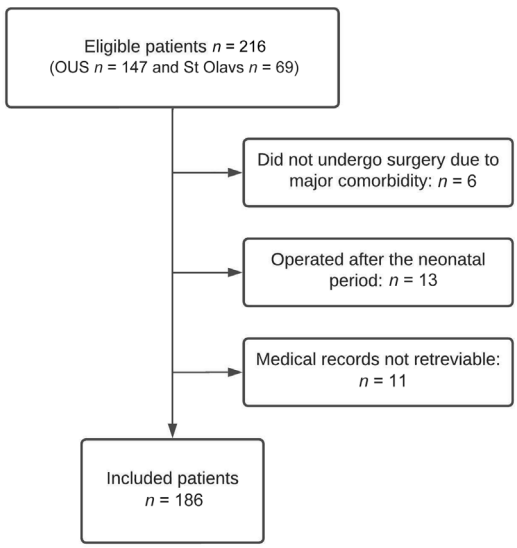

Fig. 1 Flow-chart with all identified, excluded, and included patients undergoing treatment for congenital duodenal obstruction from 1995 to 2020 in St. Olav's University Hospital and Oslo University Hospital (OUS).

The median age at operation was 2 (0–24) days, and the age at operation was higher in period 1 (1995–2003) but only significant compared with period 2 (period 2: $p = 0.012$; period 3: $p = 0.063$). CDO was repaired through an upper transverse laparotomy in 185 (99%), a supraumbilical incision in one (1%), and none had a laparoscopic repair. Eighty-eight (49%) had a TAFT placed peroperatively, and the use of TAFT increased ($p < 0.001$) throughout the study period (►Fig. 2, ►Table 1). The use of TAFT differed between the two centers (32 vs. 87%, $p < 0.001$). Neonates with TAFT got PN for a shorter time (8 vs. 10 days, $p < 0.001$) but stayed longer in the hospital (15 vs. 14 days, $p = 0.022$). The complication rate was similar between neonates with and without TAFT (32 and 26%, $p = 0.412$).

Postoperative complications occurred in 54 (29%) neonates. The postoperative complication rate, the mortality rate (►Table 3), postoperative LOS, and postoperative days with PN were stable over time (►Table 1). Nine (5%) neonates experienced serious complications. One patient had to drain pleural fluid under general anesthesia. One was reoperated due to stenosis in duodenoduodenostomy. One patient was reoperated due to a small bowel perforation of unknown origin. Anastomotic leak was observed in three patients: two after concomitant resection of a Meckel's diverticula and one in the duodenoduodenostomy. This last patient also had a peroperative cardiac arrest but was resuscitated successfully. Three patients (2%) died during the first 30 days after surgery; all had major congenital heart comorbidity. One of the deceased patients also underwent endoscopy because of hematemesis.

Discussion

The main finding in this national study of neonates undergoing surgery for CDO was that there were no changes in postoperative outcomes during a 26-year period. Contrary to our hypothesis, there was no significant reduction in either complication rate or LOS. The total complication rate in our study is somewhat higher than in other recent studies on CDO.[1,4,15] We have used the CD grading of complications, and therefore, all deviations from a standard postoperative course are recorded as a complication. We think this is the most likely explanation for the difference in total complication rate. Minor complications such as superficial wound infections not needing antibiotic therapy or unplanned TAFT removal are generally not reported in similar studies but are reported as grade 1 complications in this study. The rate of serious ($\geq$ CD3) complications related to the duodenoduodenostomy was very low, only two cases in 26 years. A further reduction of serious complications is difficult to achieve. One of the most common complications in this and other cohorts with CDO patients is infections.[1,15] Antimicrobial prophylaxis given at the right time is one of the most important interventions to reduce surgical site infections.[13] Thus, implementing routines to ensure that antimicrobial prophylaxis is given at the right time could help reduce surgical site infections in neonates with CDO. LOS in this study is in the lower range of what is reported from

Table 1 Demographics, management, and postoperative outcomes of neonates undergoing surgery for congenital duodenal obstruction in Norway during 1995–2020

	1995–2003 $n = 41$	2004–2012 $n = 83$	2013–2020 $n = 62$	*p*-Value
Birth weight, g	2.808[a] (608)	2.547 (727)	2.579[a] (702)	0.166
Gestational age at birth, wk	37.5[a] (2.5)	35.9 (2.6)	36.0[a] (2.9)	0.007
Gender, boys	17 (41.5%)	42 (50.6%)	26 (41.9%)	0.489
Down syndrome	12[a] (30.0%)	36 (43.4%)	22 (35.5%)	0.325
Additional malformations/disorders				
None	24[a] (60.0%)	28 (33.7%)	29 (46.8%)	0.019
Heart	12[a] (30.0%)	40 (48.2%)	23 (37.1%)	0.124
Gastrointestinal	7[a] (17.5%)	21 (25.3%)	16 (25.8%)	0.582
Other	1[a] (2.5%)	9 (10.8%)	2 (3.2%)	0.095
Type of obstruction				
Web	17[a] (45.9%)	25[a] (32.1%)	19[a] (31.7%)	0.297
Atresia	13[a] (35.1%)	34[a] (43.6%)	24[a] (40.0%)	0.675
Annular pancreas	7[a] (18.9%)	17[a] (21.8%)	15[a] (24.2%)	0.653
Tumor	0[a] (0%)	1[a] (1.2%)	1[a] (1.6%)	1.000
Other	0[a] (0%)	1[a] (1.2%)	1[a] (1.6%)	1.000
Prenatal diagnosis	11 (26.8%)	55 (66.3%)	33 (53.2%)	< 0.001
Age at operation, d	3[a] (0–16)	2 (0–17)	2[a] (0–24)	0.040
Type of operation				
Duodenoduodenostomy	30[a] (78.9%)	71 (85.5%)	55 (88.7%)	0.291
Duodenojejunostomy	3[a] (7.9%)	8 (9.6%)	3 (4.8%)	0.584
Duodenotomy	2[a] (5.3%)	2 (2.4%)	1 (1.6%)	0.715
Other[b]	3[a] (7.9%)	2 (2.4%)	3 (4.8%)	0.368
Transanastomotic feeding tube	9[a] (23.7%)	40 (48.2%)	39 (62.9%)	< 0.001
Postoperative days with parenteral nutrition	9.5[a] (0–21)	9[a] (0–68)	9[a] (0–71)	0.876
Postoperative length of stay	13[a] (8–124)	15[a] (5–111)	15[a] (6–99)	0.083
Discharged to home	18[a] (50.0%)	27 (32.5%)	23 (37.1%)	0.237

Note: Normally distributed numbers, mean (SD) and non-normally distributed numbers, median (min-max) are presented. The *p*-value reflects differences between all three groups. Continuous variables were analyzed with analysis of variance (ANOVA) and Kruskal-Wallis-test as appropriate. The chi-square test was applied for comparison of all categorical variables.
[a]Not all patients had retrievable information for this variable.
[b]Ladd's procedure and gastroduodenostomy.

Fig. 2 Percentage of patients (x-axis) with different managements of congenital duodenal obstruction in Norway from 1995 to 2020 two and two years (y-axis).

recent studies on CDO.[1,15,23] This suggests that also other institutions have been unsuccessful in reducing LOS in this patient population. The main factors keeping CDO patients in the hospital are the time to achieve full oral feeds and postoperative complications. Implementation of a standardized feeding protocol has shown promising results in reducing LOS in neonates with CDO.[24] Neonates in this study were fed according to surgeons' preferences.

All neonates in this study underwent a laparotomy to repair the CDO. Minimally invasive surgery is increasingly applied in neonates, and laparoscopic repair of CDO is safe and feasible.[25,26] However, there is no sound evidence that the laparoscopic approach has better outcomes for CDO than laparotomy.[25,26] As shown for several other neonatal conditions, our study demonstrates that implementation of minimally invasive techniques in neonates is slower than

Table 2 Comparison of neonates with and without prenatal diagnosis undergoing surgery for congenital duodenal obstruction in Norway during 1995–2020

	Prenatal diagnosis $n = 99$	Not prenatal diagnosis $n = 87$	*p*-Value
Birth weight, g	2,430.2[a] (636)	2,815.5 (717)	< 0.001
Gestational age, wk	35.4[a] (2.5)	37.29a (2.7)	< 0.001
Age at operation, d	1 (0–17)	5[a] (0–24)	< 0.001
Comorbidity			
Down syndrome	38 (38.4%)	32[a] (37.2%)	0.869
Associated malformations/disorders	67 (67.7%)	49[a] (43.0%)	< 0.001
Postoperative complications			
Any complication	28 (28.3%)	25 (28.7%)	1.000
Serious complications[b]	8 (8.1%)	1 (1.1%)	0.038
Postoperative days with parenteral nutrition	9[a] (0–71)	9[a] (0–65)	0.902
Postoperative length of stay, d	16[a] (6–99)	14[a] (5–124)	0.001

Note: Normally distributed numbers, mean (SD) and non-normally distributed numbers, median (min-max) are presented.
[a]Not all patients had retrievable information for this variable.
[b]Serious complications defined as Clavien-Dindo grade 3 or more.

Table 3 Postoperative complications of neonates undergoing surgery for congenital duodenal obstruction in Norway during 1995-2020

	1995–2003 $n = 41$	2004–2012 $n = 83$	2013–2020 $n = 62$	*p*-Value
Patients with complications	30 (73.2%)	59 (71.1%)	42 (67.7%)	0.526
Grade CD 1				0.066
Surgical site infection	1	3	2	
Atelectasis	0	1	2	
TAFT-related[a]	1	6	8	
Total	2 (4.9%)	10 (12.0%)	12 (19.4%)	
Grade CD 2				1.000
Surgical site infection	3	4	10	
Central line sepsis	1	5	1	
Anemia	0	2	0	
Other infections[b]	3	3	0	
Total	7 (17.1%)	14 (16.9%)	11 (17.7%)	
Grade CD 3[b]				0.283
Anastomotic leak/bowel perforation	1	2	1	
Pleural effusion	0	1	0	
Hematemesis	0	1	0	
Anastomotic stenosis	0	1	0	
Total	1 (2.4%)	5 (6.0%)	1 (1.6%)	
Grade CD 4 (Cardiac arrest)	0 (0%)	1 (1.2%)	0 (0%)	1.000
Grade CD 5 (Death)	0 (0%)	3 (3.6%)	0 (0%)	0.119

Note: Complications are graded according to the Clavien-Dindo classification (CD) and listed as the number of complications. The p-value reflects differences between all three groups. Continuous variables were analyzed with analysis of variance (ANOVA) and Kruskal-Wallis-test as appropriate. The chi-square test was applied for comparison of all categorical variables.
Abbreviation: TAFT, transanastomotic feeding tube.
[a]Clogging, dislodgement, or removal by the patient.

one may anticipate.[27] There are many barriers to implementing minimally invasive techniques in neonatal surgery, including lack of scientific evidence that minimally invasive surgery has better outcomes, technically demanding procedures, expensive equipment, and until recently, lack of instruments suited for neonates.[27] The only change in surgical treatment we observed during this long period was the more frequent use of TAFT. However, TAFT was not associated with reduced LOS or fewer complications. This is consistent with several other studies exploring the effect of TAFT in neonates with CDO.[15,16,28] Although more use of TAFT is unlikely to reduce LOS and complications, it may have other benefits, such as a reduced need for PN and earlier enteral feeding.[15,16,28]

The prenatal detection rate increased and stabilized at around 50% during the study period. A large population-based European study from 1996 to 1998 showed a detection rate of 60%,[29] which is more than twice the detection rate we found in period 1 (1995–2003). On the other hand, the detection rate during period 3 (2013–2020) is in line with the latest reports from Western populations.[1,30] We observed that neonates with a prenatal diagnosis underwent surgery earlier than those without a prenatal diagnosis. Similar findings have been demonstrated in other countries.[18,31] We also found that neonates with a prenatal diagnosis more often had serious complications and a longer postoperative LOS than those without a prenatal diagnosis. Since those with a prenatal diagnosis also had an increased frequency of additional malformations/disorders, lower birth weight, and lower gestational age at birth, these factors likely explain the higher rate of serious complications and longer LOS in neonates with a prenatal diagnosis. Previous reports are conflicting concerning the influence of prenatal diagnosis on postoperative outcomes.[18] In our series, the demographics of neonates with and without a prenatal diagnosis are too different to draw any conclusions about the impact of a prenatal diagnosis. It is also possible that patients with multiple malformations undergo more thorough prenatal investigations, increasing the likelihood of detecting a concomitant CDO.

The main strengths of this study are the multicenter national design, availability of detailed medical records, a high number of patients, few excluded patients, few missing patients, and few missing data. We had detailed information from analog and electronic medical records back to 1995. A limitation of this study was its retrospective nature with the inherent limitations of this design. Minor differences in demographic data (gestational age, type of obstruction, age at operation, and comorbidities) between neonates treated in period 1 and in periods 2 and 3 may have impacted the outcomes. Since two different investigators registered data in the two centers, minor differences in registration and categorization may have occurred. Since medical records have gotten more detailed in recent years, it is possible that some information was missed in the earlier years of the study period. Furthermore, we do not have complete data from all patients after discharge from the two centers, since some patients were transferred to their local hospitals. Therefore, there is some uncertainty related to the total postoperative LOS, total days with PN, and postoperative complications after discharge from the two pediatric surgical centers in this study.

Conclusion

Perioperative treatment and postoperative outcomes in neonates with CDO have been remarkably unchanged during the last quarter of a century. The only changes were more use of TAFT and an increased prenatal detection rate.

Conflict of Interest

None declared.

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