Laparoscopic Gastrostomy in Children with Congenital Heart Disease

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ABSTRACT

Aim: The aim of this study was to study the type and frequency of complications and change in weight after a laparoscopic gastrostomy procedure in 31 children with congenital heart disease, comparing patient groups of children with univentricular and biventricular circulation, and with completed and uncompleted cardiac surgery.

Methods: The method used was that of a retrospective study of all 31 children with congenital heart disease who underwent a laparoscopic gastrostomy at our center from 1995 to 2004.

Main Outcome Measures: Postoperative complications and body weight changes during follow-up were the main outcome measures used in this study.

Results: Minor stoma-related problems were common in both groups. Two severe complications requiring an operative intervention occurred in the univentricular circulation group. Weight was normal at birth, low at the time of the gastrostomy procedure, and did not catch up completely during the follow-up period of a mean of 20 months. There were no significant differences regarding mean weight gain between the groups.

Conclusions: The complication rate after the laparoscopic gastrostomy procedure was higher in our patient group, compared to previously studied children with various diseases. Comparisons regarding mean weight gain between the groups showed no significant differences. The mean weight gain was low, suggesting that the energy expenditure in this patient group of children with severe congenital heart disease may be even higher than previously assumed.

INTRODUCTION

MALNUTRITION AND FAILURE TO THRIVE IS A COMMON and well-known problem in the treatment of children with severe congenital heart disease. Three main factors contribute to malnutrition: insufficient oral intake, raised metabolic demands, and malabsorption. Adequate growth improves the success of cardiac surgery and influences postoperative morbidity.

Previous studies have shown that children with ventricular septal defects have 140% of normal total energy expenditure and 250% of normal energy expenditure of activity. This indicates that children with congenital heart disease may not be able to meet their elevated energy demands.

Continuous nasogastric tube feeding has been successful regarding weight gain in children with congenital heart disease. Long-term feeding is, however, associated with several disadvantages, such as repeated tube dislocations, gastroesophageal reflux, esophagitis, aspiration, and impaired development of oromotor feeding skills.
Retrospective studies of percutaneous endoscopic gastrostomy in children with congenital heart disease have reported an increase in weight.\textsuperscript{7,8} The complications of the percutaneous endoscopic gastrostomy procedures in children are well established\textsuperscript{9,10} and are mainly related to the blind puncture of the abdominal wall with the risk of perforation of the internal organs, bleeding, obstruction, or development of a gastroenteric fistula (3.5%).\textsuperscript{11}

To avoid the complications associated with percutaneous endoscopic gastrostomy, the laparoscopy-aided gastrostomy technique\textsuperscript{12–15} has been used at our center since 1994. Laparoscopy reduces the risk of unnoticed intra-abdominal injury and allows for the exact positioning of the gastrostomy site. The suturing of the stomach to the anterior abdominal wall decreases the risk of dislodgement. The placement of a primary low profile gastrostomy button eliminates the need for another anesthesia.

\begin{table}
\centering
\caption{Study data}
\begin{tabular}{lrrr}
\hline
 & \textit{Univentricular} & \textit{Biventricular} & \textit{Total} \\
 & (Unigroup) & (Bigroup) & \\
\hline
\textbf{Children} & & & \\
Number of children (male/female) & 14 (11/3) & 17 (6/11) & 31 (17/14) \\
\textbf{Cardiology} & & & \\
Blood oxygen saturation <95\% & 14 & 12 & 26 \\
Any cardiac surgery prior to laparoscopy-aided gastrostomy & 14 & 15 & 29 \\
Completed cardiac surgery prior to laparoscopy-aided gastrostomy & 2 & 13 & 15 \\
\textbf{Nutrition} & & & \\
Contact with a clinical dietician & 14 & 17 & 31 \\
Nasogastric tube feeding & 13 & 17 & 30 \\
Mean weight\textsuperscript{a} at birth (standard deviations) & 0.1 (−1 to 3) & −0.4 (−3 to 2) & −0.2 (−3 to 3) \\
Mean weight\textsuperscript{a} at laparoscopy-aided gastrostomy (standard deviations) & −1.9 (−4 to 0) & −2.3 (−4 to 0) & −2.1 (−4 to 0) \\
\textbf{LG procedure} & & & \\
Mean age at laparoscopy-aided gastrostomy in months (range) & 9 (3 to 29) & 18 (3 to 77) & 14 (3 to 77) \\
Peroperative antibiotics & 10 & 9 & 19 \\
Conversion to laparotomy & 1 & 1 & 2 \\
Mean operative time (minutes) & 37 (20 to 50) & 39 (28 to 50) & 38 (20 to 50) \\
\textbf{Follow-up} & & & \\
Mean duration (months) & 18 (0 to 42) & 22 (1 to 74) & 20 (0 to 74) \\
Death resulting from cardiac disease & 1 & 3 & 4 \\
Duration after laparoscopy-aided gastrostomy (months) & 2 & 1, 6, and 10 & 5 (1 to 10) \\
\textbf{Stoma-related problems} & & & \\
Total & 8 & 12 & 20 \\
External leakage & 4 & 8 & 12 \\
Infection & 6 & 8 & 14 \\
Granuloma & 4 & 8 & 12 \\
\textbf{Complications} & & & \\
Internal leakage & 2 & 0 & 2 \\
Duration after laparoscopy-aided gastrostomy (days) & 5 and 9 to & 5 and 9 & 5 and 9 \\
\textbf{Removal of the gastrostomy button} & & & \\
Intended & 4 & 5 & 9 \\
Mean duration after laparoscopy-aided gastrostomy in months (range) & 29 (14 to 42) & 37 (19 to 74) & 33 (14 to 74) \\
Owing to complications & 2 & 0 & 2 \\
Duration after laparoscopy-aided gastrostomy (days) & 5 and 9 to & 5 and 9 & 5 and 9 \\
Other reasons & 0 & 1 & 1 \\
Duration after laparoscopy-aided gastrostomy (months) & to & 6 & 6 \\
\textbf{Removals, total} & 6 & 6 & 12 \\
Persisting gastrocutaneous fistula & 1 & 3 & 4 \\
\hline
\end{tabular}
\textit{Note.} Patients are grouped according to type of circulation.
\textsuperscript{a}Mean age-matched body weight expressed in standard deviations.
There were no complications observed in our previous study of laparoscopy-aided gastrostomy in children with various diseases.\textsuperscript{15} Laparoscopy-aided gastrostomy has been found to be a significantly safer procedure than percutaneous endoscopic gastrostomy.\textsuperscript{16} To our knowledge, the use of laparoscopy-aided gastrostomy in children with congenital heart disease has not previously been investigated and reported.

The aim of this study was to compare two groups of patients with uni- and biventricular circulation regarding the type and frequency of complications and change in weight during follow-up after laparoscopy-aided gastrostomy procedures in children with congenital heart disease. The aim was also to compare two groups of patients with completed and uncompleted cardiac surgery at the time of the laparoscopy-aided gastrostomy procedure regarding change in weight during the follow-up.

**PATIENTS AND METHODS**

Included in this study was a consecutive cohort of 31 children with congenital heart disease who underwent the laparoscopy-aided gastrostomy procedure between March 1995 and May 2004. Demographic data are presented in Table 1. The main cardiac diagnoses as well as significant comorbidity are presented in Table 2. Cardiac surgery was performed by the pediatric cardiac surgery unit at our hospital. This unit performs between 300 and 350 cardiac operations on children with congenital heart disease each year. Approximately 15\% of these children have defects requiring the Norwood operation, resulting in univentricular circulation.

A retrospective review of pediatric charts was performed. The indication for gastrostomy was problems with nutrition or feeding that were anticipated to persist for longer than 6 months. All procedures were performed under general anesthesia, using the previously described technique.\textsuperscript{12,13,15} Perioperative prophylactic antibiotics were routinely administered. A 2- or 3-mm Verres-type needle was introduced through the umbilicus into the abdominal cavity. A 2 or 3 mm, a 0- or 30-degree optic was then introduced through the Verres cannula (MiniPort, AutoSuture; United States Surgical Corporation, Norwalk, CT) and the abdominal cavity inspected. At the selected location of the gastrostomy button, a 2-, 3-, or 5-mm trocar was introduced into the abdominal cavity under direct vision. The location was usually at the midpoint between the umbilicus and the costal margin and through the left rectus muscle.

A grasper was used to grasp the anterior stomach wall at the point selected for placement of the gastrostomy button. The grasped part of the stomach wall was exteriorized and sutured to the fascia in the abdominal wall. Through two purse string sutures, the stomach wall was opened and a gastrostomy button, the MicKey\textsuperscript{®} (Ballard Medical Product, Draper, UT), was inserted. The purse string sutures were then pulled and tied tightly. The gastrostomy balloon was inflated with approximately 6 mL of sterile water. The button size was 14 Fr, with a length

<table>
<thead>
<tr>
<th>Table 2. Main Diagnosis of Cardiac Disease and Significant Comorbidity</th>
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<tbody>
<tr>
<td><strong>Main diagnosis</strong></td>
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<tr>
<td>---------------------------------------------------------------</td>
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<tr>
<td>Univentricular circulation (Unigroup)</td>
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<tr>
<td>Hypoplastic left heart syndrome</td>
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<tr>
<td>Prenatal left ventricular infarction</td>
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<tr>
<td>Tricuspid atresia and truncus arteriosus</td>
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<td>Pulmonary atresia and intact ventricular septum</td>
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<td>Other forms of functional single ventricle</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>Biventricular circulation (Bigroup)</td>
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<tr>
<td>Pulmonary atresia with septal defect</td>
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<tr>
<td>Pulmonary stenosis</td>
</tr>
<tr>
<td>Double outlet right ventricle</td>
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<tr>
<td>Ventricular septal defect</td>
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<tr>
<td>Atrial ventricular septal defect</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>Atrial septal defect</td>
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<tr>
<td>Tetralogy of Fallot</td>
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<tr>
<td>Coarctation of the aorta and ventricular septal defect</td>
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<tr>
<td>Coarctation of the aorta and mitral stenosis</td>
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<tr>
<td>Aortic stenosis and mitral stenosis</td>
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<td>Complex combination of defects</td>
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Aortic stenosis and mitral stenosis

Complex combination of defects

Pulmonary hypertension

Enteral atresia
between 1 and 1.7 cm. Gastroscopy was used to inspect the esophagus and to verify the localization of the gastrostomy button.

Oral feeding was started as soon as the child was awake. Nutrition through the gastrostomy was started within 4 hours and continued with increasing amounts of fluid, as tolerated by the child. Bolus feeding was continued as preoperatively.

All the patients had regular contact with a dietician and all were seen at our nurse outpatient clinic. Endpoints for follow-up were the last outpatient clinic contact with the gastrostomy still in use, the closure of the stoma, or the death of the patient.

Fourteen (14) of the children had univentricular circulation defects and were undergoing, or planned for, surgical palliation by means of the three-staged Norwood operation. Seventeen (17) of the children had biventricular circulation defects that were available for surgical correction. Children were grouped regarding type of circulation—univentricular circulation (Uni-group) or biventricular circulation (Bi-group)—and regarding completion of cardiac surgery (finished Norwood surgery or correction of defect) at the time of the laparoscopy-aided gastrostomy procedure—corrected (C-group) or not corrected (N-group).

The individual change in weight after the laparoscopy-aided gastrostomy procedure was assessed by using charts for gender- and age-matched growth standard deviation scores for Swedish children. Age was approximated to age in months, and weight scores were approximated to the closest whole number in standard deviation. Data regarding the change in weight after the laparoscopy-aided gastrostomy procedure were grouped in three units; 1–12 months of follow-up, 13–24 months of follow-up, and more than 24 months of follow-up. Because of a high number of patients lost from follow-up after 24 months, data from this group were disregarded in the comparison of patient groups.

Mann-Whitney tests of two independent groups were used for statistical analysis regarding significance of differences.

This study was performed in accordance with the rules of the local Ethical Committee.

RESULTS

There were no perioperative complications and no mortality related to the laparoscopy-aided gastrostomy procedure. Two procedures were converted to laparotomy owing to adhesions after previous abdominal surgery and owing to anatomic difficulties. Both these children were excluded from data regarding frequency of complications and change in weight. For one boy, his weight at the time of the laparoscopy-aided gastrostomy procedure was missing from the chart. A few weeks later, he died from circulatory failure resulting from his cardiac disease. Four (4) patients died during the follow-up period as a result of their heart disease.

Of the 14 children in the Uni-group, there were 2 who had complications (15%) resulting from the laparoscopy-aided gastrostomy procedure. Both consisted of wound infections, leading to intra-abdominal leakage from the incision in the stomach. One (1) of the 2 children did not receive any prophylactic antibiotics. In both cases, laparotomy with closure of the gastrostomy was required.

There were no complications in the Bi-group. One gastrostomy button was removed owing to a stoma wound infection. The child presented with signs and symptoms of sepsis but was later found to have pneumonia.

Stoma-related problems were common in both groups and could be managed with local treatment at the outpatient clinic. Data are presented in Table 1. Twenty (20) children (69%) had stoma-related problems that were often recurrent. External leakage was treated by changing gastrostomy button parameters. Wound infection was usually manageable with hygienic routines and local treatment. Excessive granulation tissue, granuloma, was treated with silver nitrate cauterization.

The mean difference in individual age-matched body weight scores between the time of the laparoscopy-aided gastrostomy procedure and follow-up periods, henceforth called “mean weight gain,” are presented in Figure 1, all the children, and in Figure 2, children are grouped according to the type of circulation and completion of cardiac surgery. A comparison between the groups revealed no significant difference, as presented in Figure 2.

DISCUSSION

The 2 complications (7%) occurred in the Uni-group in those children who had not completed the three-stage Norwood operation. Their weights were $-2$ and $-3$ standard deviations at the time of the laparoscopy-aided gastrostomy procedure. This, together with our previous results of laparoscopy-aided gastrostomy procedures in 98 children with various diseases with no complication rate, might indicate that children with congenital heart disease are at a higher risk of complications than children with other diseases. This is probably more true for children with univentricular circulation, who most likely are more catabolic and, therefore, at an even higher risk of complications than other children with congenital heart disease.

Two reports documented the absence of complications with the percutaneous endoscopic gastrostomy technique in children with congenital heart disease. Although they both had short follow-up periods, the two compli-
cations in our study developed within a few days after surgery. However, the gastroenteric fistulas associated with the percutaneous endoscopic gastrostomy technique are known to be able to remain asymptomatic for many months.11 There is also a difference in the purpose of the studies, as the aim was not to establish the frequency of complications, but rather to study weight gain. In a population of children with various diseases, the frequency of gastroenteric fistula was 3.5% after the percutaneous endoscopic gastrostomy procedure.11 No gastroenteric fistulas occurred in our study.

The question of whether the addition of an antireflux procedure to the gastrostomy might promote better weight gain than a gastrostomy alone remains to be answered. A conclusive comparison is lacking. Theoretically, an antireflux operation should lead to an increase

FIG. 1. Change in weight after gastrostomy. Mean individual change in age-matched body weight score after a laparoscopic gastrostomy procedure, expressed with 10 and 90 percentiles.

FIG. 2. Change in weight after gastrostomy. Mean individual change in age-matched body weight score after a laparoscopic gastrostomy procedure, expressed with 10 and 90 percentiles. Children were grouped regarding their type of circulation—univentricular (Uni-group) or biventricular (Bi-group)—and regarding the completion of cardiac surgery at the time of the laparoscopic gastrostomy procedure—not completed (N-group) or completed (C-group). Values of statistical significances between groups (P) are presented.
in weight by reducing the losses of energy by vomiting the food. An antireflux operation was not performed in any of the children included in this study. Vomiting was not a great problem and could be coped with by a continuous feeding or frequent feeding with smaller meals. Furthermore, the children’s gastroesophageal reflux problems, such as vomiting, disappeared with time and after a successful reconstructive cardiac surgery. In these situations, an antireflux operation would have been unnecessary.

After the removal of the gastrostomy buttons, there was a need for the surgical closure of the stomas in 4 of 12 children (33%). This is in accordance with our previously published results in which approximately half of the children needed surgical closure of the stoma.18

The high frequency of minor stoma-related problems, approximately 70%, was expected and might be even higher than registered because stoma-related problems were not routinely reported from other hospitals. The problems could easily be handled in the outpatient clinic. We registred all minor problems, even those not in need of surgical intervention. We think that it is important to beware of this fact when informing the children’s guardians about the fact that a gastrostomy needs caretaking and should be performed only when necessary.

The rate of complications is high in these very sick children with a cardiac anomaly and hypoxia in their tissues. The high rate of complications is also related to the technique by which we put a corpus alien into the body. A similar rate of complications is seen after a percutaneous endoscopic gastrostomy insertion if registered on the same way we have done in this study.

In this study, it was not possible to register the individual feeding regime or the type of administered formula. All but 1 of the children had nasogastric tube feeding prior to surgery, and therefore, the gastrostomy did not necessarily cause an increase in caloric intake.

The mean weight gain of 0.4 standard deviations during the first year and 0.9 standard deviations during the second year is roughly equal to previous published results7,8 in children with congenital heart disease. The study populations are heterogeneous, making comparisons difficult. Hofner et al.7 studied 8 children for at least 6 months, whereof 4 gained more than 1.0 standard deviation and two gained more than 0.5 standard deviations. Ciotti et al.8 reported that 14 cyanotic children gained 0.2 standard deviations in a median of 211 days and 18 noncyanotic children gained 0.7 standard deviations in a median of 294 days.

A comparison between groups did not show any significant difference. A nonsignificant tendency indicated that the completion of cardiac surgery may be an important factor for weight gain. There was also a nonsignificant tendency that children with univentricular circulation were gaining weight more slowly than children with biventricular circulation.

The last step of the Norwood operation is usually performed approximately at 2 years of age, placing a majority of the Uni-group children in the N-group. Therefore, on the whole, the two groups included the same patients. One may speculate if it is the late completion of cardiac surgery or the hemodynamic of the univentricular circulation that causes the slow weight gain in these children.

The increased metabolic demand in children with univentricular circulation as well as those with uncompleted cardiac surgery might be even higher. To our knowledge, this has not been investigated. Further studies are recommended to investigate the energy expenditure in children with univentricular circulation.

**CONCLUSIONS**

Children with congenital heart disease seem to have an increased risk of complications after laparoscopy-aided gastrostomy procedures, compared to other children. The laparoscopy-aided gastrostomy procedure has previously been shown to have a lower complication rate than polyethylene glycol, and therefore, we recommend it to be the first method of choice for the placement of a gastrostomy in children with congenital heart disease.

Although there were no significant differences, growth seemed to be slower in children with univentricular circulation as well as those with uncompleted cardiac surgery. This suggests that the energy expenditure in these children could be higher than previously assumed. Possibly the caloric intake, 140% of normal energy expenditure, is insufficient. Further studies are needed to investigate the true energy expenditure in this patient group of children with severe congenital heart disease and uncompleted cardiac surgery.

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REFERENCES


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