Cardiology in the Young

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The impact of viral respiratory infection on surgical outcome of cavopulmonary shunt

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Abstract

Undetected respiratory infections may adversely affect the intrapulmonary resistance after Stage 2 or Stage 3 Fontan palliation. A few studies describe a higher risk for viral pneumonia during respiratory virus season, but none of them have focused on the effect of symptomatic viral pneumonia on in-hospital clinical course after bidirectional Glenn shunt. We analysed 77 patients who underwent bidirectional Glenn shunt surgery. Six patients were detected with pneumonia and proof of viral ribonucleic acid in tracheal mucus in the very early postoperative time. We compared them retrospectively to the remaining 71 patients regarding preoperative inflammatory signs, mortality, paediatric ICU length of stay, and ventilation time. The infection rate was not seasonal dependent. Ventilation time was significantly elongated in the pneumonia group (558 h ± 634 vs. 8.7 h ± 1.9; $p < 0.0001$) and so was the paediatric ICU length of stay (29 days ± 26 vs. 3 days±1; $p = 0.007$). Significantly more patients in the pneumonia group required extracorporeal cardiac life support postoperatively. The mortality was significantly increased in patients with pneumonia. Even subclinical viral pneumonia may cause ventilation-to-perfusion mismatch by raising intrapulmonary resistance. Recorded parameters of postoperative paediatric ICU therapy showed a significant impact of a viral pneumonia on patients after bidirectional Glenn shunt. The respiratory syncytial virus vaccination does not protect these patients from infection with other respiratory viruses. The focus should be put on preoperative diagnosis of pulmonary infections in the vulnerable group of patients with univentricular hearts.

Introduction

The staged Fontan procedure is the final common surgical pathway for all patients with univentricular hearts. The division between the systemic and pulmonary circulations is performed in two stages, a bidirectional superior cavopulmonary connection (or bidirectional Glenn operation) during infancy, followed later by rerouting of the inferior caval blood to the pulmonary arterial system (the Fontan completion).

The success of both of these stages depends on a well-developed pulmonary vascular bed which offers a low resistance to the passive flow of systemic venous blood through the pulmonary circulation. Appropriate respiratory dynamics are a crucial component of the circulation. Hill et al, using a large Paediatric Health Information System database in North America, have demonstrated a longer period of hospital stay following the completion of the Fontan procedure if the procedure was performed during the winter months (October to March), and this was associated with a larger viral respiratory burden for all paediatric admissions to hospital during this period. They have recommended avoiding the Fontan procedure during the viral respiratory season.[1] Nicolas et al, using the Paediatric Cardiac Care Consortium database specifically for the Fontan and bidirectional Glenn procedures, demonstrated additionally that mortality for the Fontan procedure (as opposed to the bidirectional Glenn, which was unaffected) is increased if the operation was performed during the viral respiratory season (arbitrarily defined as between 1 November and 31 March).[2]

Methods

We retrospectively analysed the data of all infants who underwent the bidirectional Glenn shunt for univentricular physiology between January 2015 and December 2020 in the University Hospital of Cologne, Germany ($n = 77$). We did not include patients operated on from January 1, 2021, due to the worsening of the SARS-CoV-2 pandemic. Patients with these

inclusion criteria and a suspected symptomatic pneumonia in the early postoperative time period got a throat swab for virus detection and tracheal secretion was taken for bacterial detection. The subsequent medical therapy was based on the underlying pathogen and followed international guidelines. No CHDs were excluded. Routine blood samples are taken for inflammatory parameters. The data are retrospectively taken from the National Quality and Information Management System, based on the Surgery and Procedure Code for Partial Cavopulmonary Connection. We detected six patients with perioperative onset of pneumonia and early evidence of pharyngeal virus deoxyribonucleic acid. Primary endpoint of the study was mortality. Secondary endpoints were ventilation time and ICU length of stay. Following international guidelines, all patients had been vaccinated against the respiratory syncitial virus using palivizumab (Synagis®, AstraZeneca), which all patients received once a month during respiratory syncytial virus season. We compared the pneumonia group with the non-pneumonia group with regard to preoperative inflammatory signs, intraoperative surgical data, and postoperative ventilation data with regard to ventilation time, ICU stay, and mortality. The preoperative recorded status included a standardised clinical examination with focus on the respiratory tract: it includes auscultation and percussion of the lungs, visual identification of pharyngeal redness, taking temperature, and detecting the respiratory rate. Statistical analyses were performed using IBM® SPSS®. The study was approved by the institutional review board.

Results

We detected six patients with perioperative clinical onset of pneumonia and early evidence of endobronchial viral deoxyribonucleic acid. The viruses isolated were rhinovirus ($n = 5$), influenza H1N1 virus ($n = 1$), metapneumovirus ($n = 1$), bocavirus ($n = 1$), and respiratory syncytial virus ($n = 1$). The demographic data of the pneumonia group ($n = 6$) did not differ from the control group (Table 1). The age at time of surgery was 9 months (± 6.7) and 8 months (± 5.5), respectively, ($p = 0.331$).

Preoperatively, all patients were clinically asymptomatic, with no chest X-ray signs of pneumonia. Preoperative blood tests for active inflammatory parameters did not differ significantly between the groups; C-reactive protein [mg/dl] 1.8 (± 1.5) versus 2.0 (± 3.0); $p = 0.15$; leucocytes [x10^9/l] 8.0 (± 2.7) versus 10.3 (± 3.3); $p = 0.13$; thrombocytes [10^9/l) 330.0 (± 120.5) versus 331.0 (± 99.4); $p = 1.0$. Following intubation for surgery, blood gas analysis showed no significant difference in preoperative oxygen saturation between the groups; (80% (± 5.2) for the pneumonia group versus 83% (± 8.1) for the control group; $p = 0.27$). The incision to closure time of surgery also did not differ significantly: 166 min (± 52.5) for the pneumonia group versus 151 min (± 19) for the control group; $p = 0.409$.

Although the blood values for inflammatory parameters remained similar on the third postoperative day (Table 3), there was a significant difference in ventilation times between the two groups; 558 h (± 634) for the pneumonia group versus 8.7 h (± 1.9) for the control group ($p < 0.0001$). Eighty-three per cent of the patients without a postoperative viral pneumonia were extubated within 24 h after surgery (Table 2). Adaptive to the ventilation times, the paediatric ICU stay was 29 days (± 26) for the pneumonia group compared with 3 days (± 1) for the control group; $p = 0.007$.

Table 1. Demographic and perioperative data (M = mean; ±SD = standard deviation)

Preoperative data	Pneumonia group ($n = 6$)	Control group ($n = 71$)	p - value
Age at surgery [months]	9 (± 6,7)	8 (± 5.5)	0.331
Chest X-ray (signs of pneumonia) [%]	0	0	
Clinical examination (signs of pneumonia) [%]	0	0	
CRP [mg/dl]	1.8 (± 1.5)	2 (± 3)	0.154
Leucocytes [×10^9/l]	8 (± 2.7)	10.3 (± 3.3)	0.132
Thrombocytes [× 10^9/l]	330 (± 120,5)	331 (± 99,4)	1.0

Table 2. Seasonal data

Seasonal data for total cohort ($n = 77$)	Surgery between Nov and March $n = 21$ (27.3 %)	Surgery between March and Nov $n = 56$ (72.7 %)	p - value
Extubation within 12 h	15 (71.4 %)	37 (66.1 %)	
Death	2	2	0.298

Table 3. Postoperative data (M = mean; ± SD = standard deviation)

Postoperative data	Pneumonia group ($n = 6$)	Control group ($n = 71$)	p - value
FiO2 (at transfer to PICU)	0.83 (± 0.21)	0.88 (± 0.14)	0.970
CVP (at transfer to PICU) [mm Hg]	19 (± 6)	19 (± 4)	0.791
Ventilation time [h]	558 (± 634)	8,7 (± 1.9)	< 0.001
CRP (2nd postoperative day) [mg/dl]	42 (± 23)	41 (± 24)	0.791
Leucocytes (2nd postoperative day) [× 109/l]	10.3 (± 2.0)	9 (± 2)	0.519
Thrombocytes (2nd postoperative day) [× 109/l]	212 (± 94.5)	155 (± 62)	0.112
PICU length of stay [d]	29 (± 26)	3 (± 1)	0.007
ECLS therapy [n]	2 (33.3%)	2 (2.8%)	0.001
Death [n]	4 (66.7%)	5 (6.9%)	< 0.001

CVP = central venous pressure determined in the superior vena cava.

Postoperative mortality was significantly increased in the pneumonia group (four of six patients died). Two of them required extracorporeal life support postoperatively for persistently poor systemic oxygenation, and neither of them recovered. Two other deaths resulted from H1N1-positive Influenza on day 19 after bidirectional Glenn shunt and Rhino and Boca virus detection on day 16 after bidirectional Glenn surgery, respectively. Nevertheless, there was no seasonal trend in mortality. Twenty-one patients were operated during the viral respiratory pneumonia season

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(November to March), and two patients died. The other two deaths, also caused by viral pneumonia, occurred in the cohort operated during spring and summer.

We found six patients of the control group swabbed for postoperative symptoms of pulmonary infection after their transfer to the normal ward (9^{th} to 13^{th} postoperative day). Virus detection was successful in four of the six patients. The pulmonary symptoms did not lead to an admission back to ICU in any of the six patients. Additionally, we had three patients with mild preoperative symptoms but an ambiguous infectious status, and their preoperative swab was positive for respiratory viruses. All three surgeries were postponed (6 to 16 days) due to the mild symptoms and the swab result. After improvement of the respiratory symptoms and with negative swabs, the surgeries were performed. The postoperative course was uneventful. All patients were extubated within the first day. Two of the three patients had an ICU length of stay higher than the average (3 days ± 1) of the control group (3 days, 6 days, and 11 days).

Discussion

Pre-existing viral upper respiratory tract infections in young patients undergoing cardiac surgery have been shown to be an independent risk factor for postoperative respiratory complications and duration of intensive care stay.[3] This study did not, however, demonstrate increased mortality. However, only a small percentage of patients in this study had univentricular physiology. Nicolas et al, in a large multi-institutional study from North America, demonstrated that deaths following Fontan surgery are higher (but not for the Glenn cohort) if the operation is performed during the winter months, in what the authors describe as the respiratory pneumonia virus season. The authors, however, did not provide viral infection data for their bidirectional Glenn or Fontan cohort. They speculated that the higher mortality must have been related to viral infections. Surprisingly, a similar effect could not, however, be demonstrated for the bidirectional Glenn surgical cohort. The Glenn shunt works on the basis of a well-developed pulmonary vascular bed offering low resistance to passive flow, with a low transpulmonary pressure gradient. Efficient respiratory mechanics are vital to the success of this circulation. Most Glenn procedures are performed relatively early in infancy, a time when the patients have less well-developed immune systems, and might be more susceptible to adverse effects of viral respiratory infections. Any viral pneumonia, even if subclinical, may affect this delicate balance by raising the transpulmonary gradient, and causing ventilation to perfusion mismatch, resulting in higher ventilation pressures postoperatively, and lower systemic saturation.[4] All of these factors impact negatively on the duration of artificial ventilation postoperatively and, consequently, the duration of paediatric ICU stay.

Hill et al demonstrated that the duration of hospital stay following completion of the Fontan operation was higher if surgery was performed in the winter months (October through March, in their study). They used the Paediatric Health Information System database for all inpatient hospital admissions due to viral infections, in order to quantify the background viral respiratory infections burden during the study period.

In a smaller single institution study, we provide viral data for six individual patients, in a subset of patients undergoing the bidirectional Glenn surgical procedure, and demonstrate that a proven early postoperative viral pneumonia is associated with increased complications such as prolonged ventilation time, the occasional requirement for extracorporeal life support, and a longer paediatric ICU stay. Such complications were observed regardless of whether surgery was performed in the summer or winter months. Four of the six patients with proven viral pneumonia in the very early postoperative time died with a clinically close relation to this infection, two of them in the winter months and two in the summer months. As has been described above, even among the survivors, the duration of mechanical ventilation and paediatric ICU stay was significantly prolonged.

The limitation of this study is the retrospective analysis of a single centre. Further studies are planned with a prospective approach since we are still limited in our conclusion. We assume the viruses to cause the poor outcome in the early postoperative time but have no significant proof due to the lack of viral swabs in the control group.

Routine viral sampling prior to the Glenn procedure seems to be warranted regardless of the season, in young infants most of whom are undergoing an elective surgical procedure. Our current practice with this patient population is to routinely obtain nasal swabs one day prior to hospital admission, with a view to avoiding potentially lethal complications. This does not, however, preclude the acquisition of a new viral respiratory infection in the immediate postoperative period, with resulting complications.

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Competing interests. None.

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