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*Analysis of selected risk factors for pulmonary complications
in infants after cardiac surgery procedures*

**Analiza wybranych czynników ryzyka powikłań płucnych
u niemowląt po operacjach kardiologicznych**

Key words: respiratory complications, Down syndrome, heart defects

Słowa kluczowe: powikłania płucne, zespół Downa, wady serca

BACKGROUND

Postoperative disorders of the respiratory system in infants after cardiac surgical procedures entail significant clinical problems, both because they are life threatening and due to their potential adverse effect on the final outcome of the treatment. The main causes of postoperative complications include significant changes in the vascular system, intrathoracic manipulation, potentially leading to the damage of anatomical structures, drainage of the pleural cavities, postoperative immobilization, mechanical respiration and post-perfusion syndrome. The basic clinical symptoms include changes in the pulmonary parenchyma and fluid in the pleural space. The identification of the type of changes and the risk factors related to postoperative pulmonary complications enables optimal adjustment of postoperative care strategies, including directed respiratory physiotherapy[1, 9].

The aim of the study was to identify the most common respiratory complications in patients after pediatric cardiac surgical procedures, to carry out a separate analysis of the group of infants with heart defects associated with Down syndrome and to evaluate the effect of extracorporeal circulation (ECC) time and aortic cross-clamp (ACC) time on pulmonary complications.

MATERIAL AND METHODS

The study was conducted at the Department of Cardiac Surgery and General Pediatric Surgery of the Medical University of Warsaw. The sample comprised 43 infants (23 boys and 22 girls) after surgical corrections of heart defects including: Atrial Septal Defect (ASD), Atrioventricular Septal Defect (AVSD), Double Outlet Right Ventricle (DORV) and Tetralogy of Fallot (TOF) in the age range of 0-1 years (the mean age = 4.88 ± 2.48 months). The patients after surgical corrections of heart defect without extracorporeal circulation who died during the study and the patients above the age of 1 year were excluded. The analysis of chest x-ray images was performed within 5 days after the surgery.

Based on the protocol developed for the purpose of this study, data were obtained on of ECC time, ACC time and the concomitant Down syndrome. For systematization and statistical analysis of the obtained data the patients were divided into three groups:

1. Based on the associated genetic syndrome, the patients were divided into D1 and D2 groups comprising the infants without and with Down syndrome respectively,
2. Based on extracorporeal circulation (ECC) time, the patients were divided into ECC1 and ECC2 groups with ECC time below and above 80 minutes respectively,
3. Based on the aortic cross-clamp (ACC) time the patients were divided into ACC1 and ACC2 groups with ACC time below and above 40 minutes respectively.

RESULTS

The results of the statistical analysis revealed that 34 (79.07%) of 43 studied infants developed pulmonary complications. In 9 patients (20.93%) no complications were noted, which was the reason for exclusion from the study.

The basic pulmonary complication (Figure 1.) in the studied group of patients was fluid in the pleural cavity, noted in 28 patients (31.36%). Pulmonary atelectasis was the rarest complication, noted in 14 patients (15.73%). Other reported pulmonary complications included parenchymal densifications in 22 patients (24.71%) and decreased lung ventilation in 25 patients (28.08%) (Figure 2.).

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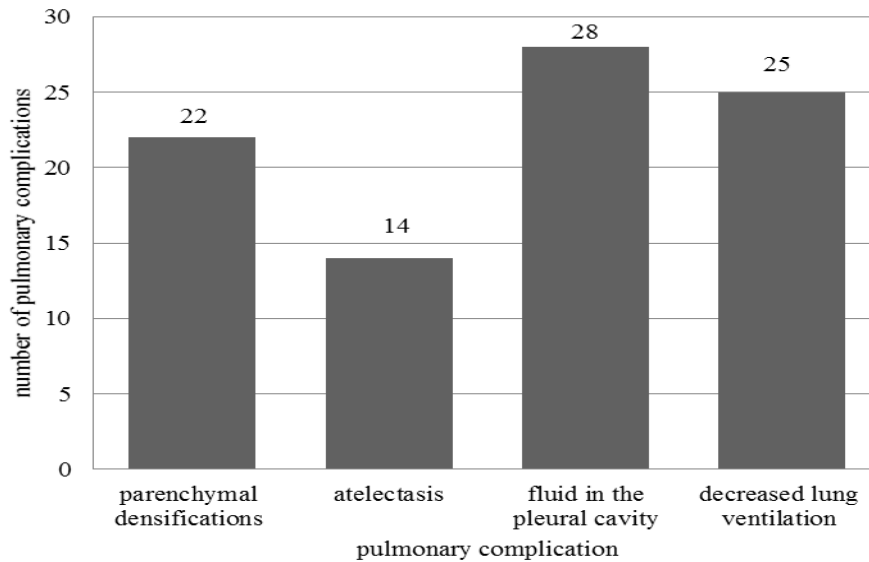


Figure 1. Pulmonary complication in the studied group of patients

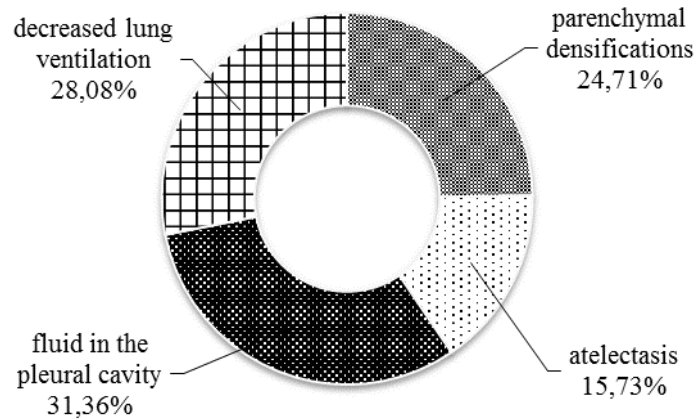


Figure 2. Percentage distribution of pulmonary complications in the studied group of patients

The analysis of the studied sample based on the presence of Down syndrome (Table I.) revealed that in D1 group (patients without Down syndrome) fluid in the pleural cavity was the most common complication, present in 18 patients (78.26%). Pulmonary atelectasis was the rarest complication in this group and it was noted in 10 patients (43.47%). Parenchymal densifications and decreased ventilation of the pulmonary tissue were found in 15 (65.21%) and 16 patients (69.56%) respectively.

In D2 group (patients with Down syndrome) the most common complications included fluid in the pleural cavity (Figure 3.), present in 11 patients (100%) and decreased ventilation of the pulmonary tissue, found in 10 patient (90.90%). The rarest complications included parenchymal densifications in 6 patients (54.54%) and pulmonary atelectasis in 6 patients (54.54%).

Table I. The analysis of the studied sample based on the presence of Down syndrome

Group	pulmonary complication			
	Parenchymal densifications	Pulmonary atelectasis	fluid in the pleural cavity	decreased ventilation of the pulmonary tissue
D1 – patients without Down syndrome	15	10	18	16
D2 – patients with Down syndrome	6	6	11	10

The statistical analysis revealed a weak correlation between the occurrence of Down syndrome and the incidence of pulmonary complications with the correlation coefficient of 0.219145 at $p=0.213047$.

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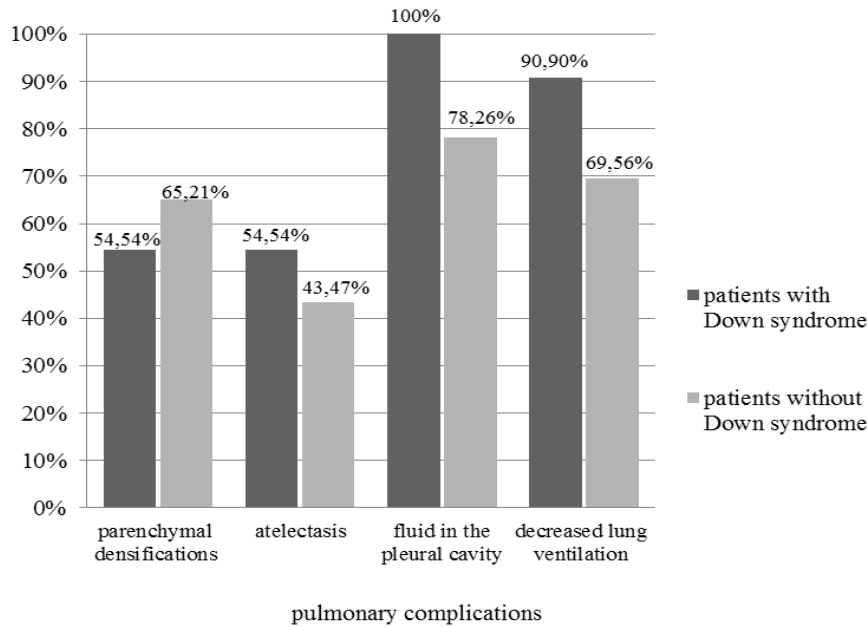


Figure 3. Percentage analysis of the studied sample based on the presence of Down syndrome

For the analysis based on the effect of extracorporeal circulation (ECC) time on pulmonary complications, the sample was divided into ECC1 and ECC2 groups with ECC time below and above 80 minutes respectively.

In ECC1 group (Table II.), the most common complications included fluid in the pleural cavity in 17 patients (77.27%) and decreased ventilation of the lung parenchyma in 16 patients (72.72%). Rarer complications included pulmonary atelectasis in 6 patients (27.27%) and densifications in the pulmonary tissue in 11 patients (50.00%).

In ECC2 group (Figure 4) with ECC time longer than 80 minutes, the most common complications included: fluid in the pleural cavity in 11 patients (91.66%), densifications of the pulmonary parenchyma in 11 patients (91.66%), decreased lung ventilation in 9 patients (75.00%) and pulmonary atelectasis in 8 patients (66.66%).

Table II. Analysis based on the effect of extracorporeal circulation (ECC) time on pulmonary complications

Group	pulmonary complication			
	Parenchymal densifications	Pulmonary atelectasis	fluid in the pleural cavity	decreased ventilation of the pulmonary tissue
ECC1 - time below 80 minutes	11	6	17	16
ECC2 - time above 80 minutes	11	8	11	9

Based on the results of the statistical analysis it was found that the duration of ECC affected the incidence of pulmonary complications in the studied sample. The obtained correlation coefficient was 0.414279 at $p < 0.01$.

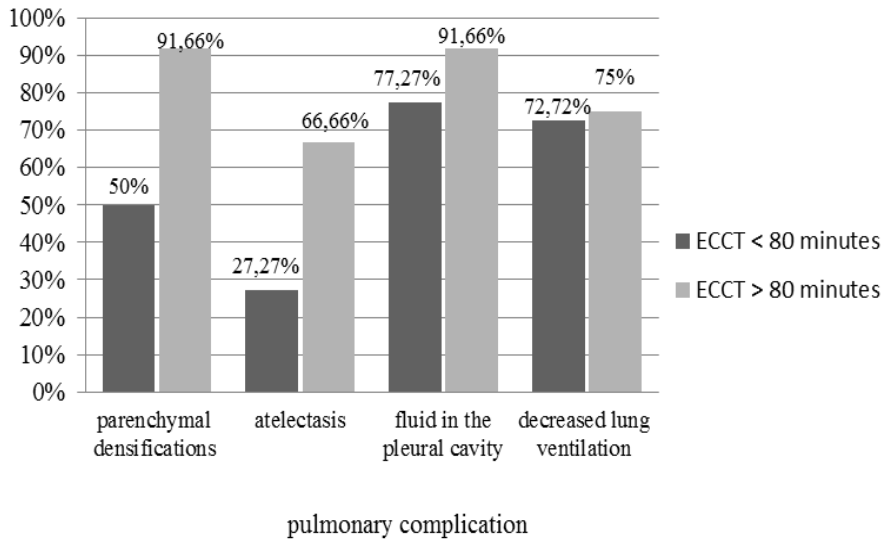


Figure 4. Percentage values corresponding to pulmonary complications in ECC groups with ECC time above and below 80 minutes. ECCT- extracorporeal circulation time

For the analysis based on the effect of the duration of aortic cross-clamp (ACC) on pulmonary complications, the sample was divided into ACC1 and ACC2 groups with aortic cross clamp (ACC) time below and above 40 minutes respectively.

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In ACC1 group (Table III.), the most common complications included fluid in the pleural cavity in 18 patients (78.26%) and decreased ventilation of the pulmonary tissue in 16 patients (69.56%). Rarer complications included densifications in the pulmonary tissue in 13 patients (57%) and pulmonary atelectasis in 5 patients (21.73%).

In ACC2 group (Figure 5.), fluid in the pleural cavity was the most common complication, noted in 10 patients (90.90%). 9 patients (81.81%), were diagnosed with decreased ventilation of the pulmonary tissue, 9 (81.81%) with of the pulmonary parenchymal densifications and 9 patients (81.81%) – with pulmonary atelectasis.

Table III. Analysis based on the effect of the duration of aortic cross-clamp (ACC) on pulmonary complications

Group	pulmonary complications			
	Parenchymal densifications	Pulmonary atelectasis	fluid in the pleural cavity	decreased ventilation of the pulmonary tissue
ACC1 - time below 80 minutes	13	5	18	16
ACC2 - time above 80 minutes	9	9	10	9

The statistical analysis revealed that the duration of aortic cross-clamp (ACC) affected the incidence of pulmonary complications in the studied sample. The obtained correlation coefficient was 0.399148 at $p < 0.01$.

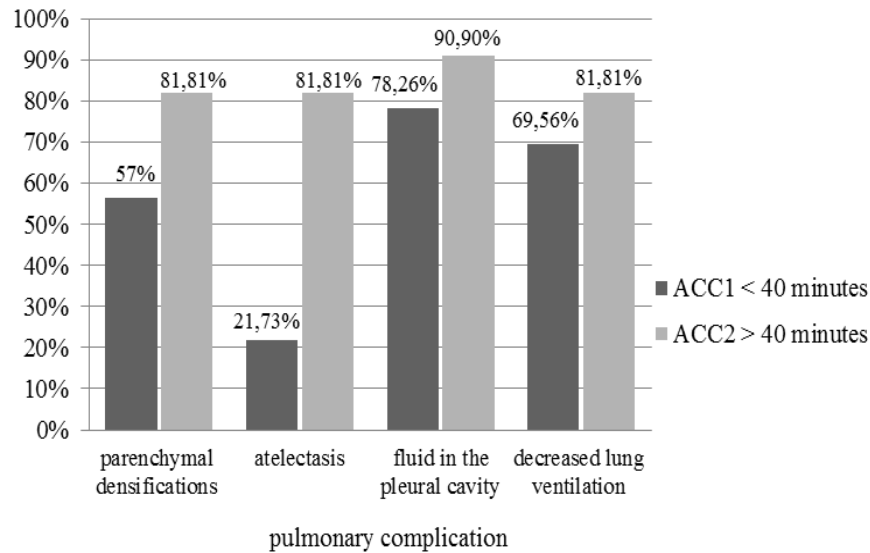


Figure 5. Percentage values corresponding to pulmonary complications in ACC groups with ACC time above and below 40 minutes. ACC- aortic cross-clamp

DISCUSSION

Based on the results, it was found that the most common complications in the group of infants after cardiac surgery procedures included: fluid in the pleural cavity (31.36%), decreased pulmonary ventilation (28.08%), parenchymal densifications (24.71%) and pulmonary atelectasis (15.73%). This finding can be explained by the fact that the use of extracorporeal circulation results in inhibition of pulmonary blood flow. The initiated body's response to this mechanism is similar to inflammatory responses. One of the stages of this response involves activation of neutrophils, resulting in increased permeability of the alveolar-capillary membrane. In consequence, the plasma penetrates the pulmonary tissue and excess fluid is cumulated in the alveoli [7, 8, 11]. Similar findings are reported by Emhardt et.al. In their study on the sample of 98 patients as much as 82% were diagnosed with atelectasis and other pulmonary complications, which correlated with the use of extracorporeal circulation (ECC) during surgical procedures [3]. Gale et al. in their study were especially concerned about the patients after cardiac surgery procedures, diagnosed with atelectasis. Likewise other researchers, they noticed that this complication was the second most frequent side effect apart from fluid in the pleural cavity [2].

The obtained data indicate a higher incidence of pulmonary complications in patients with Down syndrome than in the group of infants without Down syndrome. The observed correlation, however, is characterized by a low correlation coefficient ($r = 0.219145$) and is statistically insignificant at $p > 0.05$. Numerous

available reports, however, indicate that the prognoses of such patients after surgical procedures are very good. Cardiac surgery corrections performed shortly after diagnosis increase the chance for full recovery in these patients [2, 4, 5, 6, 13].

Based on the statistical analysis, we can conclude that the duration of ECC has a significant effect on the incidence of pulmonary complication in the studied population of patients. In the group of infants with extracorporeal circulation (ECC) time was longer than 80 minutes, fluid in the pleural cavity and parenchymal densifications were more frequent than in the group with ECC time shorter than 80 minutes. Similar findings are reported by researchers who studied samples of adults. Argawal et. al. in their study on 271 patients noticed a significant effect of ECC time on the course of postoperative care. Thida Ong et. al. in turn, showed that a longer duration of extracorporeal circulation is associated with residual lung volume and the duration of artificial ventilation, and that it can prolong hospitalization period [10,12]. Wasowicz et. al. examined the lung tissue and found that the longer duration of ECC resulted in pulmonary tissue damage.

The results obtained from the studied sample indicate that the duration of ACC has a significant effect on the incidence of pulmonary complications. A statistically significant between-group difference was observed in the incidence of complications. In the group of patients with ACC shorter than 40 minutes, significantly fewer changes were noted in the lungs. The most common complication noted in this group was fluid in the pleural cavity (78.26%). Also in the group with ACC longer than 40 minutes, fluid in the pleural cavity was the most frequent complication, observed in most of the patients (90.90%). Similar results were obtained by the researchers from other centres.

Since the duration of ACC is closely connected with ECC time, the results are similar. In the international literature, ECC time is the preferred factor.

The results obtained from this study are not only useful for physicians, but also this is a precious source of information for physiotherapists dealing with infants after cardiac surgery procedures.

CONCLUSIONS

1. The most common pulmonary complications in the studied sample of infants after cardiac surgery corrections included: fluid in the pleural cavity, decreased ventilation of the pulmonary tissue, parenchyma densifications and pulmonary atelectasis.
2. The duration of extracorporeal circulation (ECC) and aortic cross-clamp (ACC) significantly affects the incidence of pulmonary complications in infants after cardiac surgery procedures.
3. Heart defects associated with Down syndrome have no statistically significant effect on the incidence of pulmonary complications in patients after cardiac surgery procedures.

4. The presented risk factors as well as the type of pulmonary complications should be considered by the physiotherapist in the planning and implementation of physiotherapy programs in children after cardiac surgical procedures.

REFERENCES

1. Agarwal I *wsp.*: Cardiopulmonary Bypass Time and Outcomes in Pediatric Cardiac Surgery. *Critical Care Medicine*, 2012, 1.
2. Calderón-Colmenero J. I *wsp.*: Surgical treatment results of congenital heart defects in children with Down's syndrome. *Archivos de Cardiología*, 2004, 39-44.
3. Emhardt J. I *wsp.*: Chest radiograph changes after cardiopulmonary bypass in children. *Journal of Cardiovascular Surgery*, 1991, 314-7.
4. Formigari R. *i wsp.*: Better surgical prognosis for patients with complete atrio-ventricular septal defect and Down's syndrome. *Annals of Thoracic Surgery*, 2004, 666-72.
5. Gale G. *i wsp.*: Pulmonary atelectasis and other respiratory complications after cardiopulmonary bypass and investigation of aetiological factors. *Canadian Anesthesiologists' Society Journal*, 1979, 15-21.
6. Kabbani M. *i wsp.*: Postoperative cardiac intensive care outcome for Down syndrome children. *Saudi Medical Journal*, 2005, 943-6.
7. Karolczak M. *i wsp.*, (red). *Wykłady o sercu i kardiologii wad wrodzonych*. Czelej, 2008.
8. Barratt-Boyes K.: *Cardiac Surgery*. Churchill Livingstone, 2003, 734-37.
9. Principi T. I *wsp.*: Complications of mechanical ventilation in the pediatric population. *Pediatric Pulmonology*, 2010, 18 - 19.
10. Salis S. *i wsp.*: Cardiopulmonary bypass duration is an independent predictor of morbidity and mortality after cardiac surgery. *Journal of Cardiothoracic and Vascular Anesthesia*, 2008, 814-22.
11. Seghaye M. *i wsp.*: Inflammatory reaction and capillary leak syndrome related to cardiopulmonary bypass in neonates undergoing cardiac operations. *The Journal of Thoracic and Cardiovascular Surgery*, 1996, 687-97.
12. Thida O. *i wsp.*: Higher pulmonary dead space may predict prolonged mechanical ventilation after cardiac surgery. *Pediatric Pulmonology*, 2009, 457-463.
13. Thieren M. *i wsp.*: Congenital heart diseases and obstructive pulmonary vascular diseases in Down's syndrome. Apropos of 142 children with trisomy 21. *Arch Mal Coeur Vaiss*, 1998, 655-61.
14. Wasowicz M. I *wsp.*: Ultrastructural changes in the lung alveoli after cardiac surgical operations with the use of cardiopulmonary bypass (CPB). *Polish Journal of Pathology*, 1999, 189-96.

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ABSTRACT

Postoperative disorders of the respiratory system in infants after cardiac surgical procedures entail significant clinical problems, both because they are life threatening and due to their potential adverse effect on the final outcome of the treatment. The sample comprised 43 infants after surgical corrections of heart defects in the age range of 0-1 years. The analysis of chest x-ray images was performed within 5 days after the surgery. The duration of aortic cross-clamp (ACC) and extracorporeal circulation (ECC) affected the incidence of pulmonary complications in the studied sample. The statistical analysis revealed a weak correlation between the occurrence of Down syndrome and the incidence of pulmonary complications. The duration of extracorporeal circulation (ECC) and aortic cross-clamp (ACC) significantly affects the incidence of pulmonary complications. 2. Heart defects associated with Down syndrome have no statistically significant effect on the incidence of pulmonary complications in patients after cardiac surgery procedures.

STRESZCZENIE

Pooperacyjne zaburzenia czynności układu oddechowego, u dzieci po korekcjach kardiochirurgicznych, stanowią istotny problem kliniczny, zarówno ze względu na zagrożenie dla życia, jak i z powodu potencjalnie negatywnego wpływu na końcowy efekt leczenia. Grupę stanowiło 43 niemowląt po korekcji wady serca w przedziale wiekowym 0-1 r.ż. Analizie poddano wyniki zdjęć rentgenowskich klatki piersiowej, wykonywanych w ciągu 5 dni po operacji. Czas krążenia pozaustrojowego oraz czas zakleszczenia aorty istotnie wpłynęły na występowanie powikłań płucnych w badanej grupie. Analiza statystyczna wykazała słaby poziom zależności pomiędzy współwystępowaniem zespołu Downa a ilością powikłań płucnych. Czas krążenia pozaustrojowego oraz czas zakleszczenia aorty istotnie wpłynęły na występowanie powikłań płucnych w badanej grupie 2. Współwystępowaniem zespołu Downa nie wpływa istotnie na ilość powikłań płucnych w badanej grupie.

Artykuł zawiera 23372 znaki ze spacjami (17662 znaki + 428,35 cm² grafiki)