VIA MEDICA

ORIGINAL ARTICLE

Cardiology Journal
2010, Vol. 17, No. 1, pp. 20–28

ISSN 1897–5593

Significance of patient categorization for perioperative management of children with tetralogy of Fallot, with special regard to co-existing malformations

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Abstract

Background: *The aim of our study was to facilitate perioperative calculation of potential risk factors on the outcome of corrective surgery for children with tetralogy of Fallot.*

Methods: *The medical records of 81 (44 female and 37 male) out of a total of 87 patients undergoing complete surgical repair of tetralogy of Fallot between 1988 and 2004 at the Children's Hospital of the Johannes Gutenberg University of Mainz were reviewed. Patients were divided into four categories, depending on the severity of pulmonary stenosis and cyanosis, as well as on the type of pulmonary circulation.*

Results: *Additional malformations did not affect mortality rates, but did directly affect the number of pleural effusions, time of epinephrine administration, duration of surgery, bypass, and ischemia, as well as length of hospitalization and intensive care unit treatment. In contrast to longer periods of extracorporeal circulation and ischemia during surgery, which are directly related not only to more complex anatomical situations but also to higher mortality and complication rates, the much-debated question of age at surgery had no influence either on the surgical approach itself or on the post-operative outcome.*

Conclusions: *Our patient categorization, and evaluation of potential pre-operative risk factors and intraoperative parameters, should prove useful for the future planning and execution of therapeutic procedures in institutions around the world.* (Cardiol J 2010; 17, 1: 20–28)

Key words: tetralogy of Fallot, cardiac surgery

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Received: 31.03.2009 Accepted: 7.09.2009

Introduction

Tetralogy of Fallot (ToF), first described in 1671 by the Danish anatomist Niels Stensen [1] and named after the French physicist and pathologist Etienne L.A. Fallot (1850–1911), is today the most frequently occurring congenital cyanotic heart disease. It is characterized by four major morphological changes of the heart: (1) a stenosis of the right ventricular outflow and a stenosis of the pulmonary valve; (2) a ventricular septal defect; (3) an ante- and dextro-positioned overriding aortic root; and (4) a secondary right ventricular hypertrophy. According to a study at the Toronto Hospital for Sick Children, it accounts for 9.7% of all congenital heart conditions and is therefore the most frequent cyanotic vitium cordis [2]. Owing to technical advances in cardiac surgery, pediatric anesthesiology and pediatric intensive care, recent years have witnessed significant changes in the diagnosis and treatment of congenital heart diseases. The mean age of primary complete repair surgery has steadily decreased. This, based on the results of Barratt-Boyes and Neutze [3], has generated controversy over the optimal time for complete repair of ToF. Castaneda et al. [4], from the Children's Hospital in Boston, argue in favor of primary correction at any age owing to the fact that this procedure avoids the damaging effects of a palliative shunt operation. It also reduces the development of right ventricular hypertrophy and consequently the occurrence of ventricular arrhythmias. At first the latter findings did not gain widespread recognition. But with the development of the new type of prostaglandins in the mid-1970s, the arterial duct could be kept open, which created a safe basis for a low-risk early total correction [5].

The ongoing development of sophisticated interventions caused a renewed discussion about the influence of the size of the pulmonary arteries on the outcome [6–8] and of the pre-operative stimulation of their growth [9–12].

Opinions still differ as to whether early one-stage repair of newborns is preferable to multi-stage surgical intervention [13–16]. Several studies with neonates and infants were conducted at the Toronto Hospital for Sick Children, which demonstrated no difference in mortality between one- and two--stage surgery [17]. Nevertheless, total corrective surgery is preferred today to palliative shunt surgery at any age.

The present study focuses on retrospective perioperative investigations of patients diagnosed with ToF at the Children's Hospital of the Johannes Gutenberg University of Mainz between 1988 and 2004, where surgery was performed. Its aim was to facilitate a pre-operative calculation of risk by determining the influence of potential risk factors, including age, body weight, additional malformations, as well as hematocrit and hemoglobin concentration, on the outcome of the surgery. It also served to allow better judgment of the influence of intraoperative parameters, such as duration of surgery, ischemia time, bypass time, body temperature, as well as the operative procedures on the outcome and course of disease.

The results were helpful in the future planning and execution of therapeutic measures at the Children's Hospital in Mainz. The comparison of our results with those from other institutions around the world facilitated a better evaluation of the quality of intensive care and patient management, and resulted in improvements in our procedures.

Methods

The medical records of 81 (44 female and 37 male) out of a total of 87 patients undergoing complete surgical repair of ToF between 1988 and 2004 at the Children's Hospital of the Johannes Gutenberg University of Mainz were reviewed. The resulting data are described below.

The study was approved by the local bioethical committee and all patients gave their informed consent.

Statistical analysis

The exploratory part of the study consisted of a detailed statistical analysis of survival rate, frequency of specific complications, and post-operative development. Statistics were calculated using SPSS software (version 14.0). P-values below 0.05 were considered to be of statistical significance. We examined whether a statistical correlation between the various parameters and the outcome exists. 'Outcome' was defined with the help of the following seven variables:

1. Mortality within the first 10 days after surgery
2. General complications
3. Pleural effusions
4. Duration of mechanical ventilation
5. Duration of intensive care unit stay
6. Duration of hospital stay
7. Administration of catecholamines based on the duration of epinephrine administration.

Our results were evaluated in the light of recent literature.

Table 1. Additional diagnoses.

	Number of patients	Frequency (%)
Additional diagnoses of cardiac genesis		
Atrioventricular septal defect	15	18.5
Peripheral pulmonary stenosis	14	17.3
Double outlet right ventricle	12	14.8
Branching anomaly of coronary artery	9	11.1
Hypoplastic pulmonary arteric trunk	6	7.4
Persisting left superior vena cava	6	7.4
Double aortic arch	3	3.7
Functional bicuspid aortic valve	3	3.7
Aortic coarctation	1	1.2
Aneurysm of pulmonary arteries	1	1.2
Ebstein's anomaly of tricuspid valve	1	1.2
Additional diagnoses of non-cardiac genesis		
Trisomy 21	6	7.4
Cleft lip and palate	3	3.7
Dystrophia	2	2.5
Continuity of hemiazygos vein	2	2.5
Microdeletion 22q11	2	2.5
VACTERL association	1	1.2
Meningomyelocele	1	1.2
Esophageal and anal atresia	1	1.2
Pyloric stenosis	1	1.2
Hypothyroidism	1	1.2

Results

Descriptive

Patient population. The age range was 13 days to 16.2 years, with 50 patients younger than 12.7 months at surgery. Median body weight at surgery was 8.6 kg (total range: 2.6 to 47 kg) and median body size was 75 cm (total range: 44 to 162 cm).

Diagnostic groups. In contrast to other studies, the diagnosis included a differentiation into four categories, depending on the severity of pulmonary stenosis and cyanosis as well as on type of pulmonary circulation. Twelve (14.8%) patients were diagnosed with a so-called 'Pink ToF', 12 (14.8%) had an uncomplicated ToF with mostly infundibular pulmonary stenosis and only moderate cyanosis, whereas 49 (60.5%) were diagnosed with a severe pulmonary stenosis with pronounced cyanosis. Eight (9.9%) patients suffered from pulmonary atresia. Further data analysis differentiated between additional diagnoses of cardiac and non-cardiac genesis (Table 1). Overall, 57 patients had one or no additional diagnosis; 24 had two to four additional diagnoses. The most common intracardiac additional malformation in the presented cohort was an atrioventricular septal defect (AVSD) in 18.5% of the population. Also the following anatomical peculiarities were recorded: right descending aorta (13 patients or 16.1%), major aorto-pulmonary collateral arteries (eight patients or 9.9%), persisting arterial duct (nine patients or 11.1%), and anomalous origin of the coronary arteries not allowing a transanular correction (nine patients or 11.1%).

Pre-operative laboratory parameters. The average hemoglobin concentration was measured at 14.5 ± 2.9 g/dL (min. 9.6 g/dL; max. 23.0 g/dL). Out of 81 patients, 49 had a hemoglobin concentration between 10 and 15 g/dL; for 25 this was between 15 and 20 g/dL. Two patients were below or at 10 g/dL, four were over 20 g/dL. Hematocrit concentration was measured in 79 patients, with three patients at or below 30%, 33 patients at 30 to 40%, 39 patients at 40 to 60%, and four patients over 60%.

Intraoperative data collection was taken from the surgical reports of the Department of Cardiothoracic and Vascular Surgery at the University Hospital in Mainz. It showed that 39 of the operations lasted less than 237.5 minutes (with an overall range from 135–670 min). The operations involved median sternotomy with cardiopulmonary bypass, mostly in hypothermia with an intraoperative mean temperature of 26.2°C (range: 18.0–37.0°C). The bypass time for 50% of the operations was below 140 minutes (range: 80–521 min). Ischemia time was no longer than 78 minutes for half of the operations (minimum 40, maximum 205 min). In one patient, a hypothermic circulatory arrest of 59 minutes was performed at a body temperature of 18.0°C to correct additional subtotal coarctation.

Post-operative data. Duration of hospital stay was between nine and 105 days for 80 patients (no data for one patient). Half of them could be discharged after no more than 24 days. After a maximum of 60 days, 75 of the patients had been discharged, which included 64 after no more than 40 days. Five patients were treated post-operatively for more than two months. One of these remained in hospital for 105 days.

There was an equally broad span (3–93 days) of the duration of intensive care unit (ICU) stay. Forty patients could be discharged from the ICU after no more than ten days. After 20 days, 63 had been released from the ICU, while eight patients remained there for up to 40, and six between 41 and 100 days.

Half of the patients (n = 40) required post-operative ventilation for no more than four days (two days controlled and two days assisted). Six patients were ventilated with continous positive airway pressure for a maximum of four days. The minimal duration of ventilation was one day, the maximum 32 days (23 days for controlled and 15 days for assisted ventilation).

Administration of circulatory modifying drugs. All but seven patients were administered epinephrine for a mean duration of 4.3 ± 3.4 days (seven patients for 1–3 days; 20 patients between 4–7 days and 15 patients for 7+ days). Norepinephrine was administered to 30 patients (13 between 1–3 days; 11 between 4–7 days; six for 7+ days). Dobutamine was administered in four cases (only one for 7+ days). Milrinone was administered in nine cases (in two cases for less than three days, in one case for more than seven days). Fifty-four patients were given trinitrosan (in 38 cases for 1–3 days, in 13 cases for 4–7 days, and in three cases for 7+days). Natrium-nitroprusside was administered to 21 patients (in 13 cases for 1–3 days, in five cases for 4–7 days and in three cases for 7+ days). Dopamine was given to 46 patients (in 16 cases for 1–3 days, in 22 cases for 4–7 days and in eight cases for 7+ days).

Complications. Twenty-two patients had no post-operative complications, 22 had one, and 34 had between two and five complications after surgical repair. One third of the patients suffered from pleural effusion, and patients frequently faced cardiac arrhythmia. Among the 81 patients there were five post-operative deaths (four male and one female) and one late death (about six months after corrective surgery).

Results

Explorative

There was no correlation between gender or body weight and post-operative outcome. However, body weight had a slightly negative influence on the duration of hospital stay (r = –0.19), which means that, in general, higher body weight resulted in a shorter hospital stay.

While there was no correlation between the patients' age and the other variables mentioned above, we found a positive correlation between the patients' age and survival rate (p = 0.082), but this did not attain statistical significance. Post-operative mortality tended to be higher in younger patients.

The severity of diagnosis had no impact on the survival rate or on the occurrence of complications, including pleural effusions. There were also no differences in the mean time of mechanical ventilation.

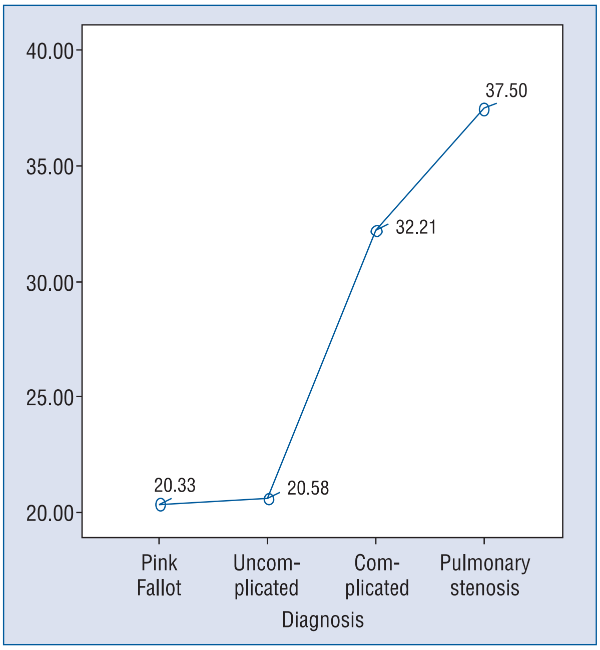

Figure 1. Mean duration of hospital stay (in days) depending on diagnosis.

However, there appeared to be a direct correlation between the severity of the diagnosis and the duration of ICU and hospital stay, as well as the need for positive inotropic support. Statistical analysis showed clear differences between the mean values in these three categories. A series of Dunnet-T3 tests allowed the identification of which particular diagnosis groups displayed these differences. The results were that patients diagnosed with 'Pink ToF' or 'uncomplicated ToF' had a significantly shorter hospital stay than patients with 'complicated ToF' or pulmonary atresia (Fig. 1). Similar results were found with regard to the duration of ICU stay (Fig. 2). In addition, it was noticeable that patients with pulmonary atresia spent more time in hospital (37.5 *vs* 32.2 days), but less time in ICU (19 *vs* 16.5 days) than patients with a 'complicated ToF'.

Most patients had no (n = 26), one (n = 30) or two (n = 14) additional diagnoses and no (n = 22), one (n = 22) or two (n = 19) post-operative complications.

A total of 32.1% of patients suffered from post-operative pleural effusions. The number of additional diagnoses showed no correlation to the survival rate, the duration of hospital stay and ICU stay. However, there were positive correlations with the complications in general (p = 0.030) as well as with pleural effusions (p = 0.012), and in particular with the mean duration of epinephrine administration (p = 0.002) (Table 2).

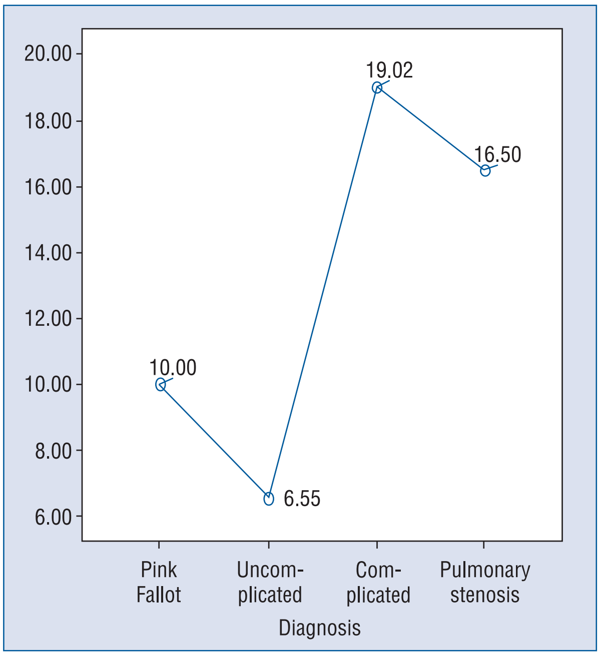

Figure 2. Mean duration of intensive care unit stay (in days) depending on diagnosis.

Table 2. Influence of additional diagnoses on the outcome.

Outcome	P
Survival	0.302*
Complications	**0.030***
Pleural effusion	**0.012***
Ventilation	0.078**
Duration of hospital stay	0.563**
Duration of ICU stay	0.389**
Administration of epinephrine	**0.002****

*Pearson χ^2 test, **univariate analysis of variance; ICU — intensive care unit

The Dunnet-T3 test could not reveal specifically how the individual diagnosis groups differed, but there was a tendency towards a longer duration of mechanical ventilation (p = 0.078) and of a higher number of post-operative complications for patients with more additional diagnoses. While there was no correlation between the number of additional diagnoses and the probability of pleural effusion, it was noticeable that all three patients with the highest number of additional diagnoses suffered from pleural effusions. Neither the Wilcoxon-Mann--Whitney-U-test, nor the correlation coefficient after Spearman, showed any correlation between C-reactive protein and the occurrence of pleural effusions, duration of ventilation, duration of hospital and ICU stay, and administration of epinephrine. Nevertheless, pre-operative C-reactive protein was higher in patients who did not survive (p = 0.014).

There was no correlation between the duration of surgery and the frequency of pleural effusions. However, there was a strong positive correlation between the duration of surgery and the duration of post-operative ventilation (r = 0.454; p = 0.000). A similar consistency between the duration of surgery and the duration of hospital stay (r = 0.270; p = 0.017), the duration of ICU stay (r = 0.456; p = 0.000) and the duration of epinephrine administration (r = 0.426; p = 0.000) could be observed.

The time of bypass had no influence on the frequency of pleural effusions. However, the patients who died subsequently displayed a significantly longer time of bypass. Simple regression analysis showed that the time of bypass could explain 27% of the variance in the time of epinephrine administration, as well as 12% of the variance of the duration of ICU stay.

The Wilcoxon-Mann-Whitney-U test showed that patients with pleural effusions and non-surviving patients on average had a longer time of ischemia (p = 0.085 and p = 0.031, respectively). Simple regression analysis showed that the time of ischemia could explain nearly 20% of the variance in the administration of epinephrine and nearly 15% of the variance in duration of ventilation.

In general, we found no correlation between intraoperative body temperature and outcome, although a difference was seen in the occurrence of pleural effusions (p = 0.054): the lower the body temperature during surgery, the higher the probability of effusions.

Duration of surgery, as well as time of bypass and ischemia, was shortest in the patient group with 'Pink ToF'. Patients with 'complicated ToF' had the longest surgery and bypass time, while the 'pulmonary atresia' group featured the longest ischemia time. Patients with fewer additional diagnoses needed a shorter time of surgery and a short mean time of bypass. We found no difference in time of ischemia between the different patient groups.

The need for more and advanced antibiotic regimes increased with the duration of use of bladder catheters, of mechanical ventilation, and of central venous catheters.

Table 3. Comparison of general and pre-operative data in Mainz, Toronto, Michigan, and Boston.

	Children's Hospital, University of Mainz	Toronto Hospital for Sick Children	C.S. Mott Children's Hospital, University of Michigan	Boston Children's Hospital
Examination period	1988–2004	1987–1994	1988–1999	1988–1996
Number of patients	81	89	61	99
Pulmonary atresia	8	4	24	26
Male/female	37/44	65/24	41/20	55/44
Age at operation	12.68 months (range: 13 days – – 16.17 years)	13 months (range: 15 days – – 17.9 months)	16 ± 13 days (range: 0–43 days)	32.9 ± 26.7 days (range: 2–87 days)
< 6 months	15	9	61	99
Body weight	8.6 kg (range: 2.62–47 kg)	8.5 kg (range: 2.6–17.6 kg)	3.2 ± 0.7 kg	3.3 ± 0.7 kg (< 30 days) + 0.2 ± 0.9 kg (31–87 days)
Trisomy 21	6	5		
VATER syndrome	1	1		
Right descending aortic arch	13	16		
Multiple aortopulmonic collateral arteries	8	7		

Discussion

The goal for all patients was the total repair of ToF, either through primary complete repair surgery, or through secondary surgery after an initial palliative shunt operation. The criteria for deciding the initial therapeutic regime could not be taken into account in the context of this study.

Risk factors

In general, all additional malformations must be regarded as risk factors [18]. Forty-six of 81 patients (56.8%) had at least one additional cardiac malformation, the most common being an AVDS (18.5%), followed by peripheral pulmonary stenosis (17.3%) and double outlet right ventricle (14.8%). Nineteen (23.5%) featured at least one extracardiac malformation or disease, and ten (12.3%) had both cardiac and non-cardiac additional diagnoses.

These figures are significantly higher than the comparable figures in the literature, which translates into a higher risk for our patients. In other studies, patients with a constellation of ToF and AVSD were generally excluded from statistical analysis because of the rarity of this combined defect, the difficulty of corrective surgery, the longer time of bypass and ischemia, and, not least, the reduced survival rate [19]. Post-operative mortality was found to be as high as 18% [20]. In our cohort, however, none of the patients with ToF and AVSD died or required re-surgery, although nine out of 15 received a Blalock-Tausing shunt prior to corrective surgery.

Patient body

Of our 81 patients, 52 underwent primary and 29 multi-stage surgical repair. Comparison with studies of similar size and with similar data collection periods (Tables 3–5) showed that the mean age of surgery lies between 16 ± 13 days and 13 months. Nearly half (39) of our patients were aged less than one year at the time of surgery (range from 13 days to 16 years). In regard to the ongoing discussion about optimal age of surgery, we found that age had no influence on the course and outcome of the surgery. Furthermore, gender had no influence on the outcome of the surgery, although it has to be noted that our gender distribution was characterized by an unusually large proportion of female patients. But on average, patients with lower body weight required an increased time of hospital stay.

The approach of sub-dividing patients into four groups according to the degree of pulmonary stenosis and the development of the pulmonary arteries, is unique to this study. It facilitated a connection between diagnosis and time of ICU and hospi-

Table 4. Comparison of intraoperative data in Mainz, Toronto, Michigan, and Boston.

	Children's Hospital, University of Mainz	Toronto Hospital for Sick Children	C.S. Mott Children's Hospital, University of Michigan	Boston Children's Hospital
Mean time of bypass	140 min (range: 80–521 min) (n = 78)	119 ± 37 min (n = 88)	71 ± 26 min	108.6 ± 278 min (< 30 days) 96.4 ± 24.8 min (31–87 days)
Mean time of ischemia	78 min (range: 40–205 min) (n = 79)	47 ± 14 min (n = 88)	45 ± 15 min (n = 52)	56.1 ± 12.1 min (< 30 days) 49.3 ± 15.6 min (31–87 days)
Transventricular access	9	79 (n = 85)	23	96
Transannular patch	39	55 (n = 87)	49	70

Table 5. Comparison of post-operative data in Mainz, Toronto, Michigan, and Boston.

	Children's Hospital, University of Mainz	Toronto Hospital for Sick Children	C.S. Mott Children's Hospital, University of Michigan	Boston Children's Hospital
Early mortality	5 patients (6.2%) within 10 days post-operatively	6 patients (6.7%) within 48 hours post-operatively	1 patient (1.6%) within 2 months post-operatively	3 patients (3%) within 30 days
Duration of hospital stay	24 days (range: 9–105 days)		19 days (range: 6–200 days)	16.5 ± 15.3 days (< 30 days) 11.2 ± 7.7 days (range: 31–87 days)
Duration of intensive care unit stay	10 days (range: 3–93 days)	5 days (range: 1–40 days)	9.1 ± 8.3 days (n = 37)	9.6 ± 13.5 days (< 30 days) 6 ± 4.7 days (range: 31–87 days)
Duration of ventilation	4 days (range: 1–32 days)	3.08 days (74 h) (range: 11 h – 30 days)	6.8 ± 7 days (n = 39)	5.1 ± 4.6 days (< 30 days) 3.5 ± 3.2 days (range: 31–87 days)
Early arrhythmias	24 patients (29.6%)	24 patients (27%)		29 patients (29%)

tal stay, and a longer time of bypass and ischemia with complicated anatomical conditions. Therefore, the proposed scheme of division seems useful for future risk management and therapy planning.

The statistical analysis of data confirmed that patients with several additional diagnoses suffered from post-operative pleural effusion more frequently and were administered epinephrine for a longer period. In addition, these patients suffered a longer time of surgery, bypass and ischemia. However, there was no influence between the number of additional diagnoses and mortality rates. This contradicts the findings of Garne et al. [21], who found an increase in mortality in patients with extracardiac malformations.

Post-operative outcome

In the immediate post-operative period, the mortality rate at Mainz was 6.2%. It was evident that age, weight, as well as primary and additional diagnoses did not have a noticeable influence on early mortality. However, the pre-operative C-reactive protein was on average higher in non-surviving patients. The course of the operation (duration, time of bypass and ischemia) showed an influence on early mortality. It was also dependent on the severity of pulmonary stenosis, the development of the cardiopulmonary system and the number of additional diagnoses. In general, the pre-operative anatomical and clinical situation had an indirect influence on the mortality rates during the first ten days after corrective surgery.

Pigula et al. [22] found a smaller body surface area and a diagnosis of ToF with pulmonary atresia to be independent risk factors for higher mortality, whereas age at surgery, gender, weight, size of pulmonary arteries and pulmonary valves, duration of circulatory arrest, time of bypass and ischemia, and the administration of inotropic drugs did not constitute risk factors. In contrast, Niwa et al. [23] demonstrated age at surgery, as well as the necessity for (and course of) re-operations, to be risk factors for late mortality.

According to Di Donato et al. [24], early mortality after corrective surgery for ToF between 1973 and 1988 was as high as 18.5%. In a retrospective study over a period of 26 years, Knott-Craig et al. [25] documented a decrease in all age groups from 11.1% before 1990 to 2.1% after 1990. A 2000 study, which included all operations of 11 different surgeons in five English institutions, showed an average mortality of 2.3% for cases with ToF (ranging from 1.6 to 6.9%, depending on the surgeon) [26]. The results at Mainz are comparable with the data in the literature and with other relevant studies.

The survival rate at Mainz was slightly higher than in the Toronto Hospital for Sick Children, but lower than in the other two institutions, but the results presented from these institutions do not include patients with ToF and AVSD. The deviations are comparable to rates in the literature. In Mainz, duration of hospital stay and ICU stay was, respectively, five days and one day longer than in Michigan. This can be explained by differences in manner of calculation. The mean duration of ventilation was roughly one day longer than in Toronto and three days shorter than in Michigan. In comparison to Boston, the mean duration of ventilation was half a day longer for older patients (31–87 days at surgery) and one day shorter for younger patients (30 days and under).

Vohra et al. [27], who compared eight papers on the topic of optimal age of correction of ToF, confirmed our finding that early primary repair is comparable to later repair in regard to mortality and re-intervention in infants aged under six months , but that length of ICU stay, requirement for ventilation and the need for inotropes is increased in patients undergoing primary surgical repair at under three months.

Conclusions

In accordance with current practice, the Children's Hospital tends to perform total surgical repair of ToF at an increasingly early age. The patient collective analyzed here displayed frequent additional malformation of cardiac and extracardiac genesis, which resulted in an increased perioperative risk. Nevertheless, the outcome of our study was comparable to those from three large specialized centers in North America: the C.S. Mott Children's Hospital at the University of Michigan [28], the Boston Children's Hospital [29], and the Hospital for Sick Children in Toronto [30].

The patients were found to be at increased risk owing to a higher percentage of cardiac and extracardiac additional diagnoses. Mortality was not influenced by the number of additional diagnoses, although patients with a higher number of them suffered more frequently from pleural effusions, needed epinephrine for a longer time, and had an increased duration of surgery, of bypass, and of ischemia. It therefore proved useful to divide patients into groups according to their diagnoses. This showed that an increased duration of bypass and ischemia resulted in a longer hospitalization and treatment in the intensive care unit, which will be of interest for future risk management and therapy planning. With regard to the much-debated optimal surgery age, no influence was noted on the surgery itself and the post-operative outcome in our patient cohort (mean age of one year).

In contrast, the effect of the surgery proved to be of significant influence on post-operative outcome. The longer the extracorporeal circulation and period of ischemia, which are related to more complicated anatomical situations and additional malformations and diseases, the higher the mortality rate and number of post-operative complications. The duration of ventilation, period of ICU stay and hospital stay is also longer. All this coincides with a higher need for catecholamines.

In this study, the mortality rate was indirectly influenced by the clinical and anatomical situation and at 6.2% proved comparable to other studies. The duration of ventilation and the extended need for a urinary catheter and a central venous catheter depended on perioperative course of operation and resulted in an increased need for inotropic drugs and advanced antibiotic regimens. The results of this study are comparable to findings in other cardiological centers at Toronto, Michigan and Boston. Differences in the duration of hospitalization can be explained by differences in organization and accounting procedures.

Acknowledgments

The first two authors listed contributed equally to this article.

The authors wish to thank Dr. Frank Erdnuess, Wiesbaden, for his help in preparing this manuscript.

The authors do not report any conflict of interest regarding this work.

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