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Original Article

Quality of life after repair of tetralogy of Fallot

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Abstract *Objective:* To determine the quality of life in individuals with corrected tetralogy of Fallot. *Methods and subjects:* Questionnaires concerning quality of life were sent to all 87 surviving patients aged between 16 and 40 years who had undergone intracardiac repair of tetralogy of Fallot and follow-up in the Wessex Cardiothoracic Unit, and to 87 age and sex matched controls, with medically treated haemodynamically insignificant ventricular septal defects. *Results:* The only significant difference found between the cases and controls was in requirements for schooling, where those with tetralogy of Fallot were more likely to require additional educational help at school ($p = 0.044$). For all other aspects of quality of life examined by the questionnaire, including social and genetic history, exercise ability, and health related quality of life, no significant differences were found. Different operative techniques, such as transjunctional patching, right ventriculotomy, and previous palliative shunting, did not affect the quality of life of our population with Tetralogy of Fallot, on average twenty years after their surgery, although the range of operative techniques was limited. Neither age at surgery, nor time since surgery, was correlated with measurements of quality of life. *Conclusions:* Those who have undergone surgical correction of tetralogy of Fallot have a normal quality of life, with few differences compared to controls.

Keywords: Health care; cyanotic congenital heart disease; follow-up

Tetralogy of Fallot is the most common cause of cyanotic congenital heart disease. Studies suggest that it accounts for up to one-tenth of all cases of cyanotic congenital cardiac malformations.[1,2] Intracardiac repair of the lesion began in 1954, first using the technique of cross-circulation, and eventually cardiopulmonary bypass. Dramatic advances have occurred in the techniques of open-heart surgery over the past 20 years. These can be attributed to technical refinement of surgery, and advances in cardiopulmonary bypass and myocardial preservation. Survival at 20 years, for those who successfully come through surgical repair, is now reported to be between 84% and 93.7%;[3,4] with the survival at 25 years being 90.9%.[5] As the prognosis improves, more emphasis is being placed on quality of life. Whilst many studies have been conducted looking at surgical outcome and rates of survival, few have looked closely at quality of life in those who survive the surgical repair. Our study assesses, in depth, the quality of life in a group of patients undergoing surgical correction of tetralogy of Fallot.

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Subjects and methods

Subjects

We selected all surviving patients with tetralogy of Fallot between the ages of 16 and 40 years who had undergone intracardiac repair and follow-up in the Wessex Cardiothoracic Unit, excluding only patients with structural chromosomal abnormalities. We found 87 such patients, who were matched with 87 controls for age and gender. The control patients had haemodynamically insignificant ventricular septal defects, unlikely ever to require surgical intervention. They were chosen because they were having follow-up in Southampton General Hospital, had the label of "congenital heart disease", but their hearts

are functionally normal, and we expected them to have a normal quality of life. The study had been approved by the Southampton and South West Hampshire Joint Research Ethics Committee.

Methods

A questionnaire pack, including a questionnaire, covering letter and stamped addressed envelope, was sent to all 174 subjects. Those who had not been seen in the outpatient clinic in the last 3 years were contacted via their general practitioners, and those who did not want to participate in the study were asked to return their questionnaire unanswered. Six weeks later, non-responders were sent a repeat questionnaire. All available notes of patients in the study group were reviewed, and details of timing and technique of surgical correction were noted.

Questionnaire

Section 1: Social and genetic history. This investigated schooling, educational achievements, employment status, activity level, and marital status. The patients were given a score for each of these attributes. It also produced information on family history of congenital abnormalities, and any known additional congenital abnormalities or serious illness in the index patient.

Section 2: Health utility index and brief psychological profile. The Health Utilities Index[6] is a validated generic measure of health-related quality of life providing a summary utility score. It comprises fifteen questions covering eight attributes: vision, hearing, speech, emotion, pain, ambulation, dexterity and cognition. Utility scores providing a unique description of the state of health are calculated using a special weighting system. These range from 0, representing death to 1.00, representing perfect health. As well as providing a summary utility score, the eight attributes could be looked at individually in order to compare the two groups. It is completed by patients, is increasingly being used in the assessment of state of health following a variety of paediatric therapeutic interventions, including survivors of childhood brain tumours and paediatric intensive care, and has been shown to be reliable for children as young as 10 years old.

The brief psychological profile reported the confidence of the patient in the future, self-esteem, medications, and thoughts about their heart. These four questions, covering four important domains, were designed with an identical format and structure to the questions contained within the Health Utilities Index.

Section 3: Exercise ability. This section was based on a questionnaire adapted from Bowyer et al.[7]

Statistical methods

Analysis was carried out using Statistical Package for Social Sciences (SPSS Inc, Chicago, Illinois, USA) and Microsoft Excel. Utility scores were generated for Health Utilities Index (Mark II), using the multi-attribute utility function dead-healthy scale.[6] The utility scores approximate continuous measures with interval scale properties, and were summarised with means and standard deviations. Student's t-test for independent groups was used to determine the significance of differences between the means of the utility scores in the two groups. Individual attributes do not have continuous interval scale properties, and are unlikely to be normally distributed, hence Mann-Whitney U tests were used to determine the significance of differences between the attribute scores for the two groups.

Results

Sample size

The sample size was fixed by the number of surviving patients in our chosen age range under follow-up at Wessex Cardiothoracic Centre. A power calculation was performed using a standard deviation and mean for the controls based on a previous study performed using the same health utilities index.

Table 1 shows the differences between the study and control means that are detectable (with 80% power) for different response rates. This is based on a two-sample t-test with a 5% two-sided significance level.

Response rates

Of the 87 patients with tetralogy of Fallot, 47 (54%) replied, and 3 were returned uncompleted. In the control group, 46 (53%) of the original 87 patients replied. The average age of the responders was 23.0 years, being 22.2 years for the non-responders ($p = 0.188$), see Table 2.

Questionnaire results

Section 1: Social history. The only significant difference found was in the requirements for schooling, where the mean for the group of patients with tetralogy of

Table 1. Power calculation at different response rates.

Response rate (%)	Overall numbers of responders	Detectable mean difference
40	70	0.053
50	87	0.047
60	104	0.043

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Fallot was significantly lower than that of the controls ($p = 0.044$), a greater proportion of those with tetralogy needing special education.

Genetic history. Of the 47 responders with tetralogy, 3 were reported to have 22q11 deletion (6.4%). Of the other 44 patients, only 3 reported they had had their chromosomes tested for 22q11 deletions. There were no known chromosomal abnormalities reported in the control group. Of the 35 probands with tetralogy of Fallot with brothers and sisters, the recurrence risk for siblings was 1.6%, with 1 sibling with a ventricular septal defect found in 62 siblings. In the control group, 37 probands had no recurrence amongst 61 siblings. None of the 13 children of 6 patients with tetralogy of Fallot, or 7 children of 4 control patients, had congenital heart disease.

Section 2 and 3. No significant differences were found in any of the individual attributes assessed by the health utilities index, the brief psychological profile, or the exercise ability sections.

The overall utility score showed that, although the mean for the control group, 0.918, was slightly higher than that of the patients with isolated tetralogy of Fallot, 0.906, there was no significant difference between the two groups ($p = 0.671$). Figure 1 shows the distribution of utility scores.

Operative technique

Details of the type of surgery performed were examined, including previous palliative surgery, presence of transjunctional patching, right ventriculotomy, age at correction, length of cardiopulmonary bypass, and year of surgery. No significant differences were found for the first three features. Only 7 patients, however, had had previous shunts, all except 4 had a transjunctional patch, and only 1 did not have a ventriculotomy. No significant correlation was found between the last three features and utility scores (Figs 2–4).

Discussion

Tetralogy of Fallot may be associated with extracardiac anomalies and genetic syndromes.[8] For example, one study reported noncardiac anomalies in almost one-third of these subjects.[9] In our initial population of 16 to 40 year olds with corrected tetralogy of Fallot, there were 5 subjects with Down's syndrome, and 1 with an unbalanced chromosomal translocation involving chromosomes 8 and 18. These patients were excluded from the study. From existing records, we were not able to exclude patients with deletion of chromosome 22q11. This is the most common known interstitial deletion found in humans, with an

Table 2. Demographics of responders versus non-responders in each group.

	Tetralogy of Fallot			Controls		
	Responders	Non responders	p value	Responders	Non responders	p value
Average age	23.3	22.9	0.871	22.9	22.2	0.417
Males:Females	24:23	25:15	0.284	16:30	29:12	0.001
Age at surgery (years)	3.7	3.2	0.190	N/A	N/A	N/A
Years since surgery	19.6	19.7	0.775	N/A	N/A	N/A

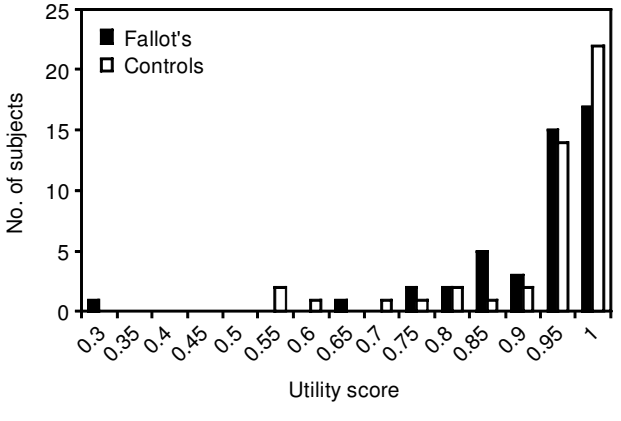

Figure 1.
Distribution of utility scores.

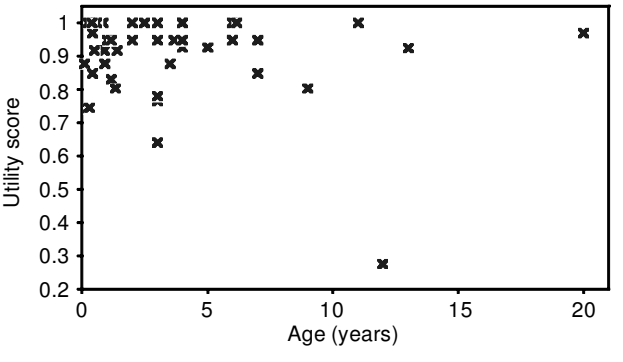

Figure 2.
Age at surgery versus the utility score.

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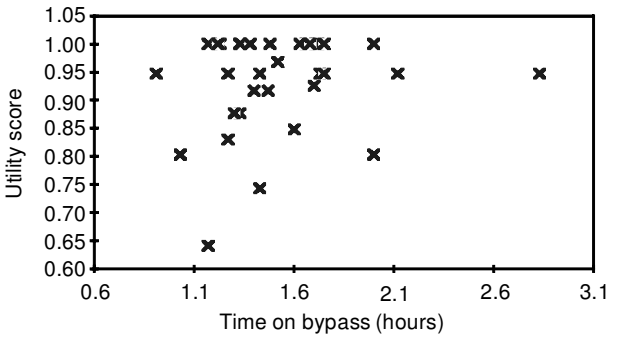

Figure 3.
Length of time on cardiopulmonary bypass versus the utility score.

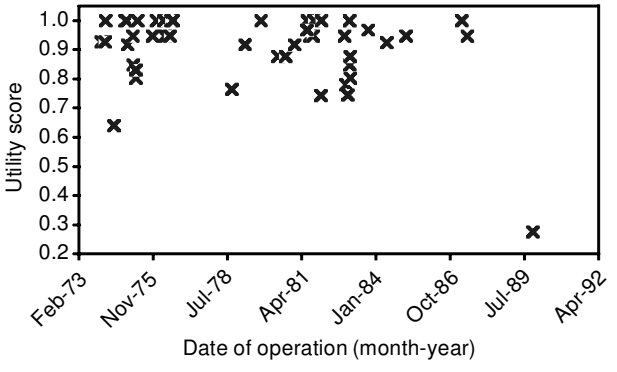

Figure 4.
Date of operation versus the utility score.

incidence of approximately 1 in each 4000 births.[10] Studies report such deletions to be present in three-tenths of patients with isolated malformations of the ventricular outflow tracts, of which tetralogy of Fallot is one.[11] We elected to include patients with 22q11 deletion in this study, since, particularly in this age group, patients may not have had their chromosomes specifically tested for this deletion. We did not set out to identify all patients with the deletion, and therefore chromosomal testing, when it had occurred, was on an "ad hoc" basis, based on a clinician suspecting the diagnosis and following suitable counselling of the patient and their agreement to be tested. Although exclusion of the 3 patients identified with 22q11 does not alter the results significantly, undiagnosed 22q11 deletion in our population may account, at least in part, for the finding of an increased requirement for special educational needs in the patients with tetralogy of Fallot.

Response rate

Overall, we had a reasonable response rate of over half. The response rate was identical for those with tetralogy and their controls, as was the overall utility score. The only difference between responders and non-responders in either group was a relative under representation of males in the control patients who responded. We do not know, however, whether the responders and non-responders are the same. We can speculate that people may not respond because they have difficulties, for example in reading the questionnaire, and that the non-responders may have a worse quality of life than responders. We could equally argue that, if patients do not perceive themselves as having any ongoing problems with their hearts, they will not be interested in such a questionnaire. It is impossible to know, therefore, the effect on the study of the non-responders. In future studies, we would seek to contact non-responders by telephone and via their general practitioner in order to try to decrease this effect.

There was a significant difference in the schooling of those with tetralogy compared to their controls. This was due to three of those with tetralogy who required special education. One of these patients has normal chromosomes, including 22q11, and the other two have not specifically been tested. The three patients with known 22q11 deletions attended normal schools.

Most patients now reach reproductive age and wish to know about the risk of having a child with congenital cardiac disease. The recurrence risk of congenital cardiac malformations for the offspring of a parent with tetralogy of Fallot is reported to be between 1.2% and 8.3%.[12,13] There were no affected offspring in our responding population, but only 13 children were identified from 6 subjects with tetralogy of Fallot that responded. The sibling recurrence risk is reported to be between 0 and 2.7%,[12] and our identified risk of 1.6% falls within this range.

One study reported that 98% of those undergoing repair of tetralogy of Fallot were physically capable of leading a normal life.[5] Another showed that 81–89% of such patients have a good quality of life.[4] But these figures were reached solely on the basis of the occupation of the patient. In our study, it is very reassuring to discover that there is no significant difference between the health-related quality of life of patients with corrected tetralogy of Fallot, on average twenty years after surgery, and their controls. Also, no significant differences were found between these two groups in any other aspect covered by the questionnaire, apart from schooling.

We considered three aspects of surgical procedure; previous palliative surgery, transjunctional patching, and ventriculotomy, because of their previously reported affect on outcome.[14–17] As expected for patients having surgery on average 20 years ago, there were very few patients with transatrial repair, or without a transjunctional patch, and this precluded meaningful comparisons.

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Age at operation is reported to be related to long term survival. The incremental risk of young age, a risk factor for early death, is now not apparent until age is less than three months.[18] Older age at repair is a risk factor for early and late death. This is due to the adverse and, to a considerable extent, irreversible effect of longstanding right ventricular hypertension,[19] which leads to right ventricular hypertrophy that begins to become irreversible by the age of four.[20] The optimal age for surgery is now thought to be between 6 months and 2 years.[21] We found no correlation between age at surgery and quality of life score. Of our patients, 29 underwent surgery below the age of 4 years, and 18 under 2 years.

It is accepted that longer duration of circulatory arrest is associated with increased risk of delayed psychomotor and neurological abnormalities after corrective surgery for congenital cardiac disease,[22] but it is reassuring that, for this group, there was no such correlation demonstrated. It is also reassuring that there is no evidence of a late decline of quality of life in our patients with tetralogy of Fallot.

We have demonstrated, therefore, that patients with surgically corrected tetralogy of Fallot have a significantly greater requirement for special education than a matched control group. For all the other aspects of quality of life we examined, no significant differences were found. This shows the quality of life after correction of tetralogy of Fallot is almost equivalent to that of the controls. Quality of life for the surviving patients, on average twenty years after surgery, was unaffected by our investigated aspects of surgical technique. Our questionnaire has provided us with a valuable tool, both to investigate the health-related quality of life of groups of patients, and also during follow-up, particularly those with symptomatic heart disease.

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