CLINICAL STUDY

Recoarctation and patients' freedom from re-intervention – A study of patients undergoing surgery for coarctation of the aorta at the Department of Cardiac Surgery of the Children's University Hospital, Bratislava

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Abstract

Background: **Many children and young adults have undergone surgery for coarctation of the aorta. Individual surgical techniques employed in the treatment of patients and their effects on incidence of recoarctation were reviewed.**
Methods and data: **Over the last ten years, a total of 201 cases of aortic coarctation were surgically treated at our department. The three forms of coarctation of the aorta recognized by the Society for Cardiothoracic Surgeons namely: isolated coarctation, coarctation with ventricular septal defects and coarctation with complex cardiac anomalies, were represented.**
Results: **19 cases of recoarctation were recorded over the period of follow-up, representing 10 % of all operated patients. On univariate analysis, the risk of recoarctation was closely linked with the following variables: use of resection and end-to-end anastomosis ($p = 0.01$), age at operation less than one month ($p = 0.0002$) and weight at operation less than 3 kg ($p = 0.01$). The risk of recoarctation was found to be highest when resection and end-to-end anastomosis was employed in neonates ($p < 0.0001$). Most cases of recoarctation as shown by the Kaplan-Meier plot occurred within the first year after surgery.**
Conclusion: **The use of simple resection and end-to-end anastomosis in neonates is associated with a high risk of recoarctation. Hence, our preferred surgical technique in neonates is the extended resection and end-to-end anastomosis, which is associated with a considerably lower risk of recoarctation in this age group.** *(Tab. 4, Fig. 5, Re. 7.)*
Key words: recurrent coarctation, coarctation of the aorta.

Patient population/data distribution

A total of 201 patients were operated on at our department between January 1992 and December 2001. 124 (62 %) of these patients were males while 77 (38 %) were females. 139 (69.2 %) patients had simple or isolated cocoarctation, 35 (17.4 %) patients had coarctation with ventricular septal defects (VSD), while 27 (13.4 %) had coarctation with complex intracardiac anomalies including hypoplastic left heart syndrome, transposition of the great arteries (TGA) and Shone syndrome.

The mean age at operation was 3.5 years (range 2 days to 18 years). A majority of patients (74 %) underwent surgical correction before the age of six years in line with our protocol, which favors early surgical repair in children.

The mean weight at operaton was 13.8 kg (range 1.7 to 67 kg).

Surgical techniques

Four surgical techniques were used in the treatment of our patients. The type of technique employed was mainly determined by the coarctation lesion, the age at presentation and the surgical trend at the time of operation. The four surgical techniques are as follows:

1) resection and end-to-end anastomosis (RETE),
2) extended resection and end-to-end anastomosis (RETE-ext.),

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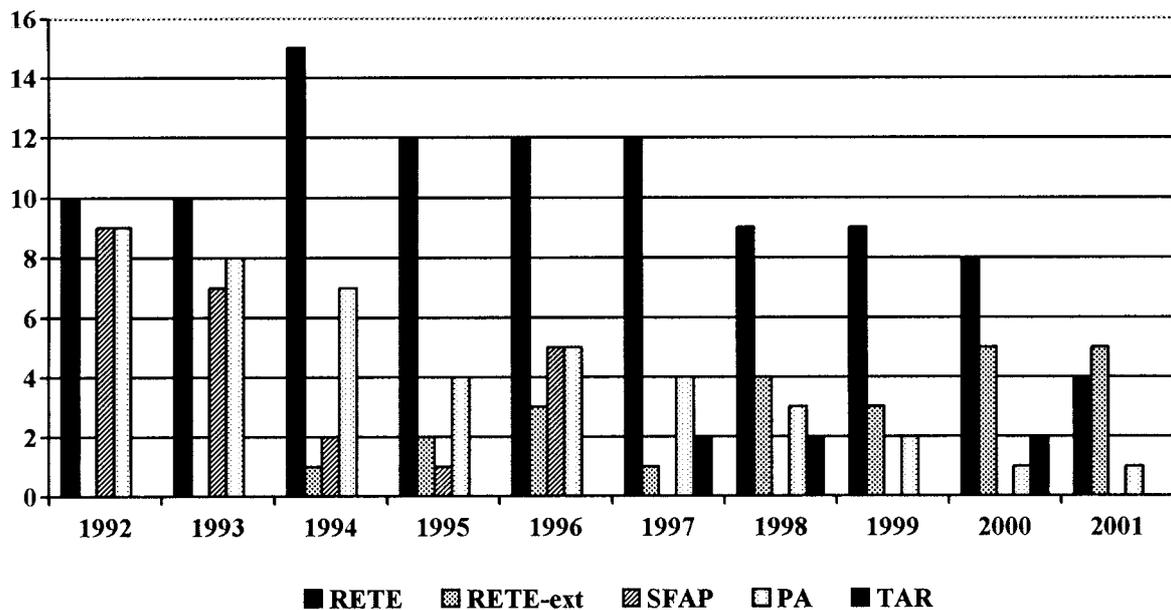Phone: +421.2.59371327, Fax: +421.2.54775766

Fig. 1. Yearly distribution of surgical techniques.

3) patch aortoplasty (Vosschulte) (PA),
4) subclavian flap aortoplasty (Waldhausen) (SFAP).

A fifth surgical technique entailed total arch reconstruction (TAR) using pericardial patch in some patients with associated aortic arch hypoplasia. On the whole, 101 patients (51 %) were treated by resection and end-to-end anastomosis, 24 patients (12 %) by extended resection and end-to-end anastomosis, another 24 patients by the subclavian flap angioplasty and 44 patients (22 %) by the patch aortoplasty technique. Total arch reconstruction was performed in 6 patients (3 %). A distribution of the surgical techniques used over the years is shown in Table 1 and Figure 1.

We can see in Figure 1 that while extended resection and end-to-end anastomosis gained in acceptance (1997 to 2001), other techniques like the subclavian flap aortoplasty and the patch aortoplasty were used to a lesser degree. In fact, the subclavian flap technique has not been used since 1997. This is due to the fact that the extended end-to-end technique is more physiological and as well enables extensive resection of the ductal tissue, thus decreasing the risk of recoarctation. There is also the need to spare the subclavian artery, thus possible complications like the steal syndrome.

Other surgical procedures

Patients with associated VSD and other intra-cardiac anomalies also underwent surgery for these anomalies. Our preferred protocol is one-stage repairs of coarctation and associated anomalies. However, some patients operated on before 1997 underwent staged repair, which entailed an initial repair of coarctation coupled with a palliative procedure such as pulmonary artery banding (PAB), followed by a definitive correction of the associated anomaly at a later date. Out of the 62 patients with associated VSD and complex anomalies, only 12 (20 %) patients had pulmonary artery banding.

Methods

ECHO-study of the aortic arch with emphasis on the site of anastomosis was performed. In addition, flow patterns across the site of coarctation repair were assessed for any signs of recoarctation. On detecting gradients more than 20 mmHg, the patients were observed and echocardiography repeated on several occasions. In cases of persistent high gradients and echo flow patterns suggestive of recoarctation, the patients were referred to cathetrization for definitive diagnosis and balloon dilatation or surgery, where necessary. A pressure gradient of over 20 mmHg across the site of coarctation repair detected on cathetrization was diagnostic of recurrent coarctation.

Patients' freedom from re-intervention was determined using the Kaplan-Meier technique. The Kaplan-Meier freedom from

Tab. 1. Yearly distribution of surgical techniques.

Year	RETE	RETE-ext.	SFAP	PA	TAR
1992	10	0	9	9	0
1993	10	0	7	8	0
1994	15	1	2	7	0
1995	12	2	1	4	0
1996	12	3	5	5	0
1997	12	1	0	4	2
1998	9	4	0	3	2
1999	9	3	0	2	0
2000	8	5	0	1	2
2001	4	5	0	1	0
Total*	101	24	24	44	6

*2 cases of intra-operative deaths were not included.
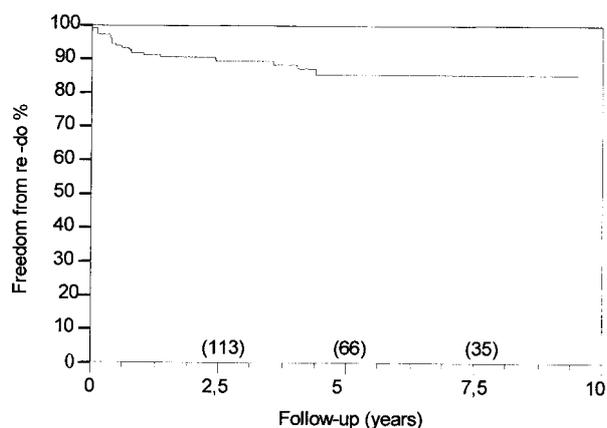
Fig. 2. Overall freedom from re-intervention. Patients at risk are in parenthesis.

re-intervention represents the percentage of patients, who did not require any surgical re-do or balloon dilatation due to recoarctation over the period of follow-up.

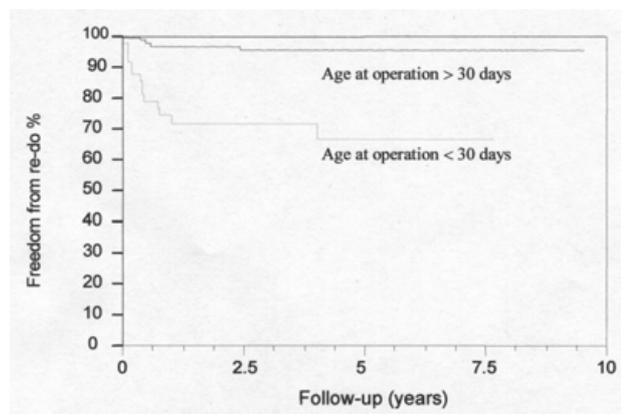**Recoarctation and freedom from re-intervention**

19 (10 %) cases of recurrent coarctation were recorded over the period of follow-up. The diagnostic criterion for recoarctation, as earlier mentioned, was a post-operative gradient of more than 20 mmHg recorded on cathetrization. Of the 19 patients with recoarctation, 5 underwent surgical re-do, 12 underwent balloon dilatation while 2 cases were treated first by surgery and later by balloon angioplasty.

Using the Kaplan-Meier technique, patients' freedom from re-operation and balloon angioplasty following recurrent coarctation was determined. The graph in Figure 2 shows that a greater part of the cases of recoarctation and subsequent intervention occurred in the first year following surgical treatment. A second "wave" of recoarctation occurred around the fifth year after operation. About 90 % of operated patients did not require any re-intervention in the first two years following surgery. At nine years of follow-up, freedom from re-intervention was 87 %. A total of 21 re-interventions in 19 patients were carried out over the period in question.
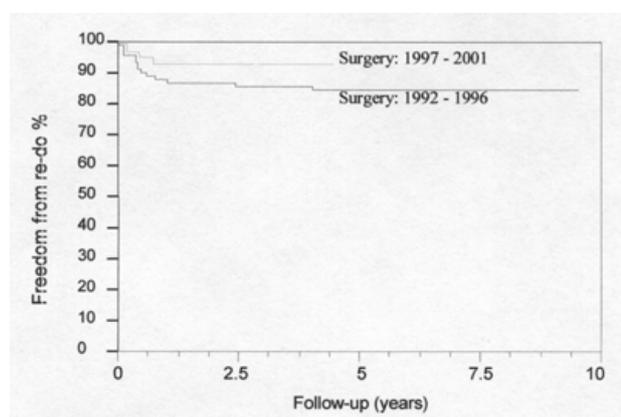
Tab. 2. Recoarctation according to employed surgical techniques. Age at operation <30 days.

Surgical technique	*No of re-CoA (neonates)	*Total No undergoing surgery (neonates)	Percentage
RETE	10	31	32
RETE-ext.	1	13	7.7
SFAP	0	11	0
PA	0	1	0
TAR	1	2	50
Total	12	58	20.7

*Only surviving patients are represented.

Fig. 3. Freedom from re-intervention according to age at operation.

Fig. 4. Freedom from re-intervention according to time of surgery.

Detailed analyses of patients' freedom from re-intervention showed a significant difference ($p<0.0001$) between those who underwent surgery within the first month of life and those who were operated on at a later age (Fig. 3). The rate of recoarctation and thus, re-intervention was much higher in the former. A higher freedom from re-intervention was recorded in patients operated on after 1997 than in those operated on before this period (Fig. 4). This could be attributed to the increase in the use of extended end-to-end anastomosis in neonates and a shorter period of follow-up. In all, 9 (29 %) of the surviving 31 neonates operated on before 1997 had recoarctation compared to 3 (11 %) of 26 neonates operated on after 1996.

Factors associated with recoarctation

On univariate statistical analysis, the following factors were closely associated with the occurrence of recoarctation:

1) Type of surgery

Patients who underwent resection and end-to-end anastomosis were at a greater risk of recoarctation (re-CoA) than were those who underwent other surgical procedures ($p=0.01$). Of the 19 cases of recoarctation, 15 (79 %) were patients who under-

Tab. 3. Recoarctation according to employed surgical techniques. Age at operation >30 days.

Surgical technique	*No of re-CoA (age >30 days)	*Total No undergoing surgery (age >days)	Percentage
RETE	3	58	5
RETE-ext.	0	6	0
SFAP	1	7	14
PA	0	43	0
TAR	0	3	0
Tota	14	121	3.3

*Only surviving patients are represented.

Tab. 4. Factors associated with recurrent coarctation.

Factors	Univariate analysis (P)	Multivariate analysis (P)
1. Resection and end-to-end anastomosis	0.01	0.5
2. Age less than one month	0.0001	0.002
3. Weight less than 3 kg	0.008	0.2
4. RE-T-E and age less than one month	<0.0001	0.003

Fig. 5. Incidence of recoarctation in neonates and older children.

went resection and end-to-end anastomosis, 2 had extended end-to-end anastomosis while the remaining 2 patients underwent subclavian flap angioplasty and total arch reconstruction respectively. None of the patients who underwent patch aortoplasty had recoarctation. 12 of a total number of 58 surviving neonates had recoarctation. 10 of these neonates were treated by resection and end-to-end anastomosis, 1 by extended end-to-end anastomosis, while 1 underwent total arch reconstruction. The distribution of recoarctation according to age and surgical techniques is shown on tables 2 and 3.

2) Age at operation less than one month

Patients operated on before the age of 1 month were much more likely to have recurrent coarctation than those operated on at a later age (p=0.0002). Figure 5 illustrates the incidence of recoarctation in these two groups of patients.
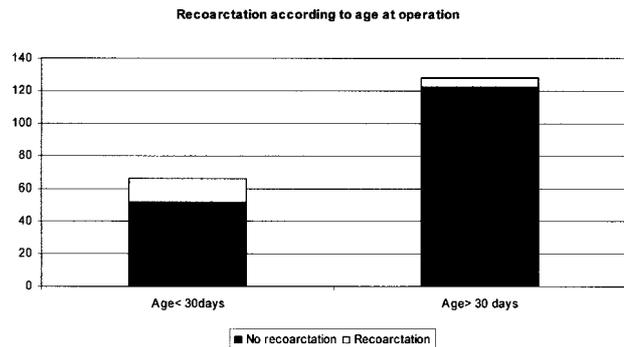
3) Weight less than 3 kg at operation

A higher rate of recoarctation was detected in pre-term babies or neonates weighing less than 3 kg at the time of surgery (p=0.01).

4) A combination of the above factors

The likelihood of recurrent coarctation is highest when resection and end-to-end anastomosis is employed in the treatment of neonates. Both univariate and multivariate statistical analyses show a very strong correlation between these two factors and the occurrence of recoarctation (p<0.0001), as opposed to the use of extended resection and end-to-end anastomosis in this age group (p=0.6).

On multivariate analysis (Tab. 4), age <1 month was statistically more significant than weight <3 kg in the occurrence of recoarctation p=0.002 as against p=0.2. Similarly, the use of resection and end-to-end anastomosis in neonates proved to be a more significant risk factors for recoarctation than its use in older patients.

Discussion

Our study has shown a recoarctation rate of 10 % over a mean period of 5 years. This, by all standards, is quite encouraging and compares favorably with results from some centers. It is also a far cry from the early days of surgical treatment of coarctation in infants when recoarctation rates as high as 60 % were reported. In their recent work, McElhinney et al (1) of the Children's Hospital of Philadelphia reported an 82 % freedom from re-intervention at five years of follow-up. Their work centered on neonates and infants less than 3 months of age at the time of surgery. A review of the same age group in our series showed an 85 % freedom from re-intervention at five years. At ten years of follow-up, we recorded a 75 % freedom from re-intervention in this age group. We identified two main factors associated with recoarctation and the need for re-intervention – age/weight at operation and use of simple resection and end-to-end anastomosis in neonates. Younger age at operation as a risk factor for recoarctation was identified by McElhinney et al. as well as in other works by van Heurn et al (2), Wu et al (3 and Fenchel et al (4). The preference of extended resection and end-to-end anastomosis to simple resection and end-to-end anastomosis in neonates and infants has also been pointed out by van Heurn et al. As we noted, the extended resection technique has become our surgical method of choice in neonates and young infants since 1997 and our findings has proved that it is indeed a worthy choice. Hence it is associated with a lower risk of recurrent coarctation than simple resection and unlike the subclavian flap, enables total resection of ductal tissue and does not involve resection of the subclavian artery. the limitations of this study lie in its retrospective nature and the need for a binding definition of the term "recoarctation". Our protocol, which strictly adheres to results obtained only on patient catheterization, is widely used in other centers (1–4). Defining recoarctation based on gradients measured by Doppler Echo can be misleading, as

our experience and those of others (1) have shown. Anyhow, it is possible that a few patients with residual or recurrent recoarctation may not have been detected since the conventional value of 20 mmHg may not apply to all patients. In addition, determining the exact time of recoarctation may prove difficult. Despite these limitations, we believe that this piece of work, like some others before it, has succeeded in shedding light on the present state of surgical repair of coarctation of the aorta and has indicated the need for the use of extended resection in neonates and infants.

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