The use of absorbable monofilament polydioxanone suture in pediatric cardiovascular operations

Growth of suture lines and anastomoses is required for long-term success after the repair of congenital cardiovascular anomalies. Polydioxanone, an absorbable monofilament suture material, has been used in a variety of operations since April, 1983. Twenty-two of the 46 procedures were coarctation repairs. Complete repairs for anomalous pulmonary veins and transposition of the great arteries, as well as Fontan procedures and systemic-pulmonary shunts, have been performed. Angiographic, gross, and microscopic examination showed good healing. There was no anastomotic disruption or aneurysm formation. The results with this absorbable vascular suture have been uniformly encouraging in a follow-up of up to 30 months.

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Infants with congenital heart disease frequently require surgical intervention early in life. Improvements in operative techniques, myocardial protection, and cardiopulmonary bypass techniques have allowed repair of cardiovascular anomalies within the first years of life with excellent immediate results. Failure of a repair to grow commensurate with the growth of the child, however, can necessitate reoperation within months or years. The suture line must grow, after the repair of many lesions, to assure a continued good outcome and excellent long-term results.

Polydioxanone (PDS, Ethicon, Inc., Somerville, N. J.), an absorbable monofilament suture, was evaluated in our laboratory.1 Its strength and handling properties were good, and the results in a growing piglet model demonstrated the superiority of this material over nonabsorbable polypropylene in permitting normal growth of aortic anastomoses. The present study was undertaken to evaluate polydioxanone in the repair of congenital cardiovascular anomalies in patients.

Patients and methods

This study, begun in April, 1983, was approved by the clinical investigations committee at our institution.

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Informed consent was obtained from the parent(s) of each patient entered into the protocol.

Forty-one patients (aged 2 days to 8 years) underwent a total of 46 operations (Table I). The patients were divided into those with systemic arterial anastomoses, those with primarily atrial anastomoses, and a miscellaneous category. Patients were followed up postoperatively by both the surgeon and the pediatric cardiologists. Repeat cardiac catheterizations were performed on 10 of the patients in this series from 2 months to 20 months after their initial operations.

Results

Systemic arterial operations.

Repair of coarctation of the aorta and interrupted aortic arch. Twenty-two patients underwent repair of coarctation of the aorta. Nineteen patients from 3 days to 2.1 years of age underwent subclavian flap angioplasty with 6-0 polydioxanone sutures applied in a continuous running technique. Most of these patients had congestive heart failure and were treated initially with digoxin, diuretics, and prostaglandin E, to improve their hemodynamic and metabolic parameters. Ten of the patients have undergone cardiac catheterization since the operation and no impressive gradients across the repairs have been found (peak systolic gradients were all less than 10 mm Hg). A representative aortogram is shown in Fig. 1.

Two older patients (aged 2.3 and 7.3 years) had repair of the coarctation by resection and end-to-end anastomosis. In both cases, the posterior row was completed with 5-0 polydioxanone suture in a continuous running horizontal mattress technique. The anterior half of the anastomosis was completed with interrupted
Table I

<table>
<thead>
<tr>
<th>Operation</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senning operation for TGA</td>
<td>7</td>
</tr>
<tr>
<td>Arterial switch operation for TGA</td>
<td>3</td>
</tr>
<tr>
<td>Coarctation of the aorta</td>
<td></td>
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<tr>
<td>Subclavian flap angioplasty</td>
<td>19</td>
</tr>
<tr>
<td>End-to-end anastomosis</td>
<td>3</td>
</tr>
<tr>
<td>Interrupted aortic arch</td>
<td>2</td>
</tr>
<tr>
<td>Modified Fontan operation</td>
<td>3</td>
</tr>
<tr>
<td>Anomalous pulmonary venous return</td>
<td>5</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>Pulmonary artery sling repair</td>
<td>1</td>
</tr>
<tr>
<td>Blalock-Taussig anastomosis</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
</tr>
</tbody>
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Legend: TGA, Transposition of the great arteries.

Fig. 1. Postoperative aortogram after subclavian flap repair of coarctation of the aorta with polydioxanone suture.

sutures. Two patients with interrupted aortic arch had a double flap repair with both the left carotid and left subclavian arteries used for angioplasty.

One patient in this series was recatheterized twice after the initial operation, so that anastomotic growth could be determined. This newborn infant had coarctation, patent ductus, and a ventricular septal defect and underwent ligation of the patent ductus arteriosus and a subclavian flap repair of the coarctation as a neonate. Repeat catheterizations were performed 2 months and 20 months after the initial operation. Measurements were taken and the percentage of increase in the various aortic segments was compared. These findings showed growth of the ascending aortic segment to be 67% over the 18 month interval, growth of the transverse aorta 77%, of the anastomotic area 180%, and of the descending aorta 59%. At this last catheterization, the diameter of the repair area was 4.5 mm compared with the descending aortic diameter of 4.3 mm.

There were no operative deaths (0/24). Five of these patients died late, two after repair of Taussig-Bing anomaly by an arterial switch operation and two after repair of their complex congenital cardiac lesions. One died 6 months postoperatively of mitral stenosis. Autopsy showed a well-healed anastomosis (Fig. 2) and microscopy showed healing of the suture line (Fig. 3). Outpatient follow-up examinations have shown femoral pulses to be excellent in all patients. Arm and thigh blood pressure measurements, when done, have shown no gradients over 10 mm Hg. This group of 22 patients has been followed up for a mean of 20.3 months since the operation.

Atrial operations.

Anomalous pulmonary venous return. Five patients, 0.2, 0.2, 0.4, and 2.3 months, and 4.6 years of age, underwent repair of anomalous pulmonary venous return (four with total anomalous veins and one with partial anomalous veins). One patient had severe lung disease and died of respiratory failure 9 months postoperatively. There was no obstruction at the suture line in this patient at autopsy, and the other four patients are doing well clinically.

Senning operation. Seven patients, aged 6 weeks to 15 months, with transposition of the great arteries with or without VSD underwent Senning operations. Continuous polydioxanone suture (5-0) was used for all atrial suture lines in constructing the intra-atrial baffle and closing the new left atrium. Because of the predisposition for early postoperative caval narrowing from purse-stringing of the continuous suture line around the venae cavae, we now recommend using interrupted sutures in closing the (new) left atrium around the inferior and superior cavae. Two patients died during the early postoperative period (<30 days) and postmortem examination revealed excellent healing of all suture lines in which polydioxanone suture was used. The other five patients have been followed up for 10 to 29 months.
Fig. 2. Gross examination of the aorta in an infant 6 months after repair of coarctation of the aorta by subclavian flap angioplasty with polydioxanone. A, Aorta. SF, Subclavian flap.

Fig. 3. Photomicrograph (original magnification × 90) of subclavian-aortic anastomosis shown in Fig. 2. Tiny chords of residual suture are seen within the suture hole beneath the intima. The difference in density of elastic fibers of aorta (left) and subclavian artery (right) is apparent, but mature fibrous tissue continuity indicates excellent healing. A, Aorta. SF, Subclavian flap.

(mean 20.8 months) and are doing well without clinical evidence of baffle leak or obstruction.

*Modified Fontan procedure.* Two patients, aged 5 years and 8 years, underwent direct anastomosis of the right atrium to the pulmonary artery (Kreutzer-Fontan procedure). Both patients are doing well 9 and 30 months postoperatively.

*Miscellaneous operations.* One patient underwent repair of a pulmonary artery sling at 2.3 years of age by division of the left pulmonary artery at its origin and reanastomosis to the main pulmonary artery with polydioxanone. This patient is doing well 7 months postoperatively. Three patients, aged 1 day, 5.1 months, and 17.8 months, had Blalock-Taussig subclavian–pulmo-
nary artery anastomoses performed with 6-0 polydioxanone. An everting running mattress technique was used posteriorly and a simple running technique anteriorly. All three patients are doing well, and we have plans for later corrective repair of tetralogy of Fallot, transposition and ventricular septal defect, and double-outlet right ventricle.

Discussion

The use of absorbable suture material for vascular anastomoses was first proposed in the 1950s. Catgut suture was used experimentally and clinically with good results. Polyglycolic acid (Dexon, Davis & Geck, American Cyanamid Company, Wayne, N. J.) and polyglactin 910 (Vicryl, Ethicon, Inc., Somerville, N. J.), which are both absorbed by 1 month postoperatively, have also been tested in vascular anastomoses in the laboratory and clinically, abroad, with good results. Another synthetic material, polydioxanone (PDS, Ethicon), is more slowly absorbed by simple hydrolysis and can be made into usable monofilament strands of larger size than these other absorbable materials. Polydioxanone is slightly stronger, initially, than polypropylene, it retains nearly 50% of its tensile strength at 1 month and it is not completely absorbed for 6 months. We have evaluated polydioxanone extensively in vascular applications in a growing piglet model and have found it to be safe and superior to nonabsorbable suture material. In these studies there were instances of intraluminal polypropylene suture material with adherent thrombus 6 months postoperatively. This was not seen in anastomoses performed with polydioxanone. Because of its handling characteristics, its ease of passage through tissues, and its prolonged strength, polydioxanone was chosen as the best absorbable suture material for clinical use in pediatric cardiovascular operations.

It has been shown in a comparison between absorbable polyglycolic acid suture material and nonabsorbable polypropylene that the integrity of an anastomosis is dependent upon healing rather than upon the permanent strength of suture materials. We regard absorbable vascular suture material as having specific advantages only in applications where growth of a suture line is important. We continue to use nonabsorbable sutures when nonviable biomaterials are used. Despite microscopic tissue ingrowth into vascular prostheses, strength of the suture line is the primary concern, and the use of absorbable suture is not appropriate. Similarly, we have not used absorbable sutures with prosthetic patches.

In the present study, follow-up cardiac catheterizations have been performed in 10 patients. Peak systolic gradients have been unimpressive. No evidence of aneurysm dilatation has been found on aortography. In the single patient who had two postoperative catheterizations, anastomotic growth was documented without evidence of aneurysm. Autopsies were performed in four of the eight patients who died during the study and gross and microscopic examinations revealed no anastomotic failures and good healing of the anastomoses, as seen in Fig. 3.

Although the length of follow-up is too short to allow comment on the long-term benefits, the use of polydioxanone suture has been shown to be safe and reliable in clinical pediatric cardiovascular operations. There have been no complications attributable to this suture material and the short-term results (up to 30 months) are excellent. Late follow-up will be necessary to determine the full benefits of polydioxanone suture in anastomotic growth.

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