to 8 weeks in children and for 8 to 10 weeks in teenagers. This time period is required for new cartilaginous rib growth from the perichondrium and secure attachment of the cartilage to the normally positioned sternum.

For the selected older children and teenagers requiring the placement of a substernal strut, the postoperative management and release to full physical activity is the same. The strut is removed on an outpatient basis under light general anesthesia by opening the lateral few inches of the previous incision. This is done 6 to 9 months after the primary repair.

On the basis of our experience and that of other surgeons, we believe that children who suffer from a pectus defect with its structural compression, cardiopulmonary dysfunction, and cosmetic impact should be offered operative repair. With current diagnostic and operative techniques, the pectus excavatum deformity can be safely repaired with full expectation of excellent long-term results.

References

1. Ravitch MM. Congenital deformities of the chest wall and their operative correction. Philadelphia: Saunders, 1977.
2. Haller JA, Peters GN, Mazur D, White JJ. Pectus excavatum: a 20 year surgical experience. J Thorac Cardiovasc Surg 1970; 60: 375–83.
3. Haller JA, Shermeta DW, Tepas JJ, et al. Correction of pectus excavatum without prostheses or splints: objective measurement of severity and management of assymetrical deformities. Ann Thorac Surg 1978; 26:73–79.
4. Shochat SC, Csongradi JJ, Hartman GE, et al. Moire photography in the evaluation of anterior chest wall deformities. J Pediatr Surg 1981; 16:353–57.
5. Haller JA, Kramer SS, Lietman SA. Use of CT scans in selection of patients for pectus excavatum surgery: a preliminary report. J Pediatr Surg 1987; 22:904–6.
6. Nakahara K, Ohno K, Miyoshi S, et al. An evaluation of operative outcome in patients with funnel chest diagnosed by means of the computed tomogram. J Thorac Cardiovasc Surg 1987; 93:577–82.
7. Blickman JG, Rosen PR, Welch KJ. Pectus excavatum in children: pulmonary scintigraphy before and after corrective surgery. Radiology 1985; 156:781–82.
8. Bevegard S. Postural circulatory changes at rest and during exercise in patients with funnel chest, with special reference to factors affecting the stroke volume. Acta Med Scand 1962; 171:695–713.
9. Beiser GD, Epstein SE, Stampfer M, et al. Impairment of cardiac function in patients with pectus excavatum with improvement after operative correction. N Eng J Med 1972; 287:267–72.
10. Cahill JL, Lees GM, Robertson HT. A summary of preoperative and postoperative cardiorespiratory performance in patients undergoing pectus excavatum and carinatum repair. J Pediatr Surg 1984; 19:430–33.
11. Peterson RJ, Young WG, Goodwin JD. Noninvasive assessment of exercise cardiac function before and after pectus excavatum repair. J Thorac Cardiovasc Surg 1985; 90:215–60.
12. Hecker WCh, Procher G, Dietz HG. Results of operative correction of pigeon and funnel chest following a modified procedure of Ravitch and Haller. Z Kinderchir 1981; 34:220–27.
13. Shamberger RC, Welch KJ. Surgical repair of pectus excavatum. J Pediatr Surg 1988; 23:615–22.
14. Willital GH. Operationsindikation-Operationstechnik bei brustkorbdeformierungen. Z Kinderchir 1981; 33:244–52.
15. Scherer LR, Arn PH, Dressel D, et al. Surgical management of children and young adults with the Marfan syndrome and pectus excavatum. J Pediatr Surg (in press).

Discussion

DR. MARK M. RAVITCH (Pittsburgh, Pennsylvania): This is a good experience. Dr. Haller quite rightly emphasized the point that this deformity imposes a definite physiologic abnormality on these patients, and that the degree of abnormality that is determinable by our clinical laboratory examination is not necessarily proportional to the symptoms the patient has.

It is uncommon for the younger patient to have any symptoms at all, although we have seen dysphagia in newborns and have operated on them with success.

Dr. Haller is quite right. We operate any time we recognize the significant deformity, if the mother doesn't faint away when operation is proposed.

In about 1948 at the University Surgeons I presented the history of a man with his second bout of cardiac failure and atrial fibrillation with a severe pectus deformity. We showed a few things in him by the physiologic studies that we could do then, notably a right ventricular pressure curve not unlike the one in congestive failure with ascites.

At that time Herb Meyer, a very astute clinician, said after we pointed out that by and large we never found anything abnormal by cardiovascular catheterization or respiratory function test, that "When you develop more sophisticated and more accurate examinations and examine the right things, you will," and of course, that has now happened in examinations done all over the world.

We have minor points of difference with Dr. Haller in addition to the age of operation. I think it is easier to do the operation on small children. I think the fact that they don't anticipate the operation is great. I think most all of you would like not to anticipate operations. The operation does not seem to cause any particular trouble because of age of the small patients.

He points out in the manuscript that for years he hadn't used blood at all, and we first discovered this in the little babies and finally as we got older and better for a while, until we reached the other side of the curve, we got to the point where we just didn't use blood on anybody. This can be quite a bloodless operation.

We still like the midline incision, which we think gives better access and is no less unsightly. You had better predict to your patients or their families that you have no control over the healing. There may be a keloid and they may be sorry they had the operation done because the scar is so unsightly.

We have experimented with a variety of methods of closure that haven't seemed to make any difference.

I am interested that Dr. Haller believes that the disturbances of respiratory function have been better documented than the disturbances in cardiac function. I believe myself that the cardiac problem is probably the more severe. You almost always have compression of the right ventricular outflow tract. That has been shown over and over again, and it shows beautifully in the CAT scans.

As for the studies that we have been doing prior to operation–x-ray and physical examination. We have got enough CAT scans, angiograms and so on to illustrate any number of articles or talks. They are very costly. A thousand dollars or so to add to my slide collection seems an unfair burden on Medicare, the patient, Blue Shield, or whomever, and I don't think that it adds to the result.

About the only time in recent years that we have been using physiologic testing has been in adults who we thought claimed an exaggerated physiologic deficit and on whom we are unwilling to operate unless we could prove that there was such a deficit and because there is likely to be something whacky about somebody who waits until he is 25, 30, or 35 years old before coming to you for an operation like that. He is looking for success on the beaches, in the board room, in the bedroom, or wher-

ever, and you can't guarantee that kind of success by altering the shape of his sternum.

I think this is an important series, a well-studied series, and one that has had good results, and I congratulate Dr. Haller and his group.

DR. J. L. TALBERT (Gainesville, Florida): Dr. Berry, Dr. Jones, Members of the Association, and Guests: I especially appreciate the opportunity to comment on this paper because I had the privilege of working with Mark Ravitch and Alex Haller during many of the formative years in the development of the procedure you have heard described today.

Certainly the authors must be congratulated on presenting a unique series from the standpoint of large patient numbers, standardization of the operative procedure, careful analysis of the operative indications, and documentation of the excellent results. I should also emphasize the importance of the long-term follow-up because you really can't tell what the final result is going to be in pectus patients until you have followed them for at least 10 years.

Clearly, this presentation should dispel the myth still perceived by many pediatricians and family practitioners regarding the inherent danger of the operative procedure for pectus excavatum and the unpredictability of outcome. The results achieved at Hopkins have also been substantiated by our own series at the University of Florida with over 100 cases using a technique comparable to that described today. In that group there have been no deaths. As Dr. Ravitch has emphasized, there is almost no necessity for blood transfusion. Cases of morbidity have essentially been limited to postoperative atelectasis and fever and there have been no wound infections or seromas with use of wound-suction catheter drainage. The average hospitalization has been approximately five days and there has been less than a 1-% rate of recurrence, results comparable to those documented by Dr. Haller in the manuscript that he has not been able to fully cover today.

We concur with the optimal timing of the operation as Alex has presented it: that is, between 5 and 6 years of age when the procedure is clinically indicated, because we feel that there is a progressive narrowing of the AP diameter of the chest wall that produces secondary deformities of the bony components of the ribs as well as the cartillaginous elements that will later render the technical procedure more difficult to perform.

We have also adopted the use of the Blades' metal strut for routine stabilization in the older patient and we even use it in patients aged less than 11 years when they have severe deformities, because we feel that we can better control the final contour of the chest wall that is achieved. We have usually left these struts in for 1 year after operation and we emphasize the ease and simplicity of their removal as an ambulatory procedure.

The use of the struts has allowed us to become more aggressive in the management of the older patients with more severe deformities because, as a consequence of the added stabilization that they provide, we have been able to resect the deformed bony components as well as the cartillaginous components of the ribs and thereby achieve an improved anterior chest wall contour.

In this regard I would ask Dr. Haller if he has had a similar experience.

I would also ask him if he has observed any problems at the level of the second and third cartillages where he has stair stepped the proximal and distal segments in order to create a stabilizing "tripod".

I have observed several instances of cartillaginous overgrowth that have resulted in cosmetically distracting infraclavicular bulges as a consequence of this maneuver and I have, therefore, tended to omit this element of the repair when a stabilizing metal bar has also been employed.

I have also felt that an active postoperative exercise regimen to enhance shoulder and anterior chest wall musculature is an important component of the over-all management, and I wonder again if Dr. Haller has any comments on this aspect of the treatment.

Finally, I feel that the authors' clarification of the role of operative repair in the management of the Marfan's patient with pectus excavatum is especially helpful and I concur with their conclusions that delayed intervention is preferable because of the high risk of recurrence.

It has also seemed to me that the actual incidence of the Marfan's syndrome in this group of patients with pectus excavatum is higher than has been previously appreciated by our medical colleagues, and I would question Dr. Haller if he has had similar experience.

DR. J. ALEX HALLER (Closing discussion): As I think every one in this audience realizes, when Dr. Ravitch spoke, that was the final word because it was he who developed the fundamental operative procedure for Pectum Excavatum. The questions he raises are done so that I can highlight some of the earlier comments that were made.

He does bring up a very important point about the cost of the CAT scan. We have been doing it on a prospective basis to see if it might be an objective way of measuring the severity because we still have problems with trying to communicate to our referring physicians exactly why we believe a specific child should be operated on. We use only one CT scan centered through the most severe part of the pectus deformity so it is not a full CT scan series.

Dr. Ravitch has emphasized over the years that he was convinced there were physiologic abnormalities long before we had good functional studies to document them. I am not personally convinced, though, that the cardiac component is as severe as the pulmonary one.

One of the striking features of evaluating these children is to ask them to inhale when you are examining their defect. When they do so, the sternum does not move forward with inflation of the lungs. They expand their chests entirely laterally in a type of double-bucket-handle motion. It is that characteristic feature of breathing that I think interferes with the normal dynamics of breathing and ultimately is responsible for the compliance abnormality that decreases pulmonary function. Whether there is a cardiac component or not is not as clear.

Dr. Talbert has emphasized the importance of long-term follow-up. Until you have followed a child through the pubertal growth spurt, you cannot be certain that they will continue to have a good long-term result because this is a growth abnormality in the first place, and there may be additional growth abnormalities later on; but I think, following teen-age growth, you can be certain that they will not have any further difficulty. That takes a long time in terms of follow-up but is an important concept.

Dr. Talbert mentioned Dr. Blade's substernal stainless steel bar. Jim, the only reason I call it an "Adkins' splint" is because it was Dr. Paul Adkins as Dr. Brian Blade's resident who first suggested that he use the substernal stainless steel bar for support.

Is rib-bone removal, as well as cartillage removal, necessary in the teen-ager with severe deformity? I doubt it and we have not removed the bony ribs. I was interested in your experience from that standpoint.

Have we seen troublesome overgrowth at the tripod support area? Only transiently in the children, but usually by one year or one and one half years afterward that tripod bump has smoothed out because the pectoral muscle has grown on top of it. It is not a long-term cosmetic problem.

Do we give them special postoperative exercises? We do not. Normal children exercise all the time. It has been our feeling that we should omit contact activities for 6 to 8 weeks, but thereafter their normal activities will correct their postural abnormalities. Finally, how frequently do we see the Marfan Syndrome in children?

More and more Marfan Syndrome is being diagnosed in young children. If you think about it, one of the primary indications of a Marfan abnormality is extraordinary height in a teenager after the pubertal growth spurt–when you see a very tall, 6-and-one-half- to 7-foot teenager! Such growth is not obvious in 4- and 5-year-old children and so unless there is a familial incidence, the Marfan Syndrome may be difficult to detect early. But our pediatric geneticists are picking that up earlier, and I think they are, therefore, presenting these patients to us for consideration of repair at younger ages.

Children with the Marfan abnormality should be treated the same as a teenager or young adult; because of their connective-tissue abnormality, they need the additional substernal stainless steel bar support. Without a bar we have found a high incidence of recurrence.