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Discussion

DR. ALDEN H. HARKEN (Denver, Colorado): It really is a privilege to watch these kinds of studies evolve. I would suggest, Dr. Wells, that this is a beautiful preemptive example of your Presidential Address, "The Surgical Sciences." Dr. Cox has taken a very common and debilitating clinical problem, taken it to the laboratory, solved it in the laboratory, then applied it to patients, and then perhaps equally important, promoted, stimulated, and encouraged the application of this therapy in other clinics such as our own. I have two questions.

Dr. Cox, you allude to atrial fibrillation causing two objective and one subjective problems. The two objective problems are thromboembolism and atrial transport function. The thromboembolic problem is a very real one with atrial fibrillation. However, you filet the atrium into multiple channels, thus detouring an impulse from the SA node down to the atrioventricular node, and incise that atrium down into these channels that are simply electroanatomically incapable of sustaining a re-entrant rhythm. You indicated it was pretty easy to cut the atrium up like that and indeed it is. Putting it back together again is a little bit more daunting. In fact, as a surgeon, you look down and it looks like a lawn mower accident. But you have all of these suture lines. Do you have either microscopic or macroscopic evidence of the relationship between the thromboembolic process and those suture lines at days, weeks, months or years?

The second question concerns the atrial transport function. When we looked at atrial transport with atrial fibrillation in patients relative to their ventricular function, folks with good

ventricles did not seem to benefit from the standard textbook 10% to 20% from the atrial kick. However, as their ventricular function deteriorated, there was a dramatic dependence on the atrial kick. Have you been able to relate the augmentation or enhancement of cardiac output or any other parameter to the restitution of sinus rhythm relative to left ventricular function?

Again I think this is a beautiful example of basic application taken to the clinics and then proliferated throughout the country. Dr. Cox, you are to be congratulated.

DR. RICHARD M. ENGELMAN (Springfield, Massachusetts): Similar to what Dr. Harken just commented on, I rise to congratulate the authors on this development of a new procedure that clearly has an important place in our surgical armamentarium. As with any new technique, it must be duplicable in other centers. Indeed, Dr. Cox has taken it upon himself to educate many interested surgeons in this technical challenge, and as Dr. Harken has hinted, this is quite a daunting technical challenge.

Our own group is only one of many exposed by Dr. Cox to this technique, and we have used the Maze procedure with long-term success, albeit our experience is clearly more limited than Dr. Cox's. In our limited experience on late follow-up, the atrium not only contracts synchronously but by echocardiography contributes to ventricular filling. And I, as Dr. Harken commented, would echo that atrial contractility is important most predominantly in the presence of left ventricular dysfunction.

Clearly, however, eliminating atrial fibrillation, as Dr. Cox as pointed out, is valuable for a whole host of reasons, not just its ability to synchronously contract with the ventricle.

I would ask Dr. Cox the following two questions. What approach does he use in the presence of a giant left atrium? And what percent of patients are in a sinus rhythm or a sinus mechanism on leaving the operating room?

DR. IRVING L. KRON (Charlottesville, Virginia): I also echo Dr. Harken's comments in that the buzz word at the National Institutes of Health today is translational research. That is a basic concept taken to the clinical arena, which is sort of what surgeons have done for years. In this case Dr. Cox took the basic electrophysiology to an operation that actually works. He has not only long-standing good results, but the concept has been corroborated by others.

I have two questions. What are the contraindications to this operation? Should this be used in every patient who needs a valve operation and has atrial fibrillation?

DR. JAMES L. COX (St. Louis, Missouri): First, Dr. Harken, from whom I learned a great deal about arrhythmic surgery myself many years ago, asked about the evidence of late thromboembolism in relation to the suture lines.

One of the nice things about having a lot of other surgeons do this procedure is that you always learn something from them. The first surgeon to really learn this operation outside our own institution and apply it in fairly large numbers was Pat McCarthy from the Cleveland Clinic. Dr. McCarthy had the

unfortunate situation of having an operative death at 3 weeks postoperatively, at about the same time we had our first one. Interestingly enough, they were both in patients with hypertrophic obstructive cardiomyopathy (HOCM). He did an autopsy on his patient 3 weeks postoperatively and could not find the suture lines from inside the heart. I think most congenital heart surgeons are aware that the patches used to close atrial septal defects and suture lines in the atrium very quickly cover over, thereby reducing or eliminating the risk of thromboembolism. I had made a habit of anticoagulating all my patients before that time, but neither he, nor any of the other surgeons I know, anticoagulate patients routinely postoperatively. The only patients that I anticoagulate routinely, and I do so only for 3 months, are patients who have had previous thromboembolic events or patients in whom the atrium is quite thick and when closing it, there is a fair amount of raw surface turned to the inside. In those patients, I cover them with anticoagulation for 6 weeks to 3 months.

Dr. Harken also asked a question about the relationship between the importance of the atrial contraction in the presence of normal ventricular function and patients who have abnormal ventricular function. As implied by Dr. Engelman, the atrial contribution to cardiac output becomes more important as the ventricular function becomes poorer.

In the first 70 patients, we did formal postoperative electrophysiology studies at 6 months postoperatively. We were not able to induce atrial fibrillation in a single patient during those studies. However, we also did atrioventricular sequential pacing *versus* ventricular pacing; in other words, we compared cardiac output during synchronous atrial contraction with no atrial contraction. There was approximately a 20% increase when we paced the atrium as opposed to allowing it to be asynchronous.

Once we were able to document in 70 consecutive patients that the atrium did contribute to overall cardiac function, we stopped performing those postoperative studies.

Dr. Engelman asked about how we handle giant left atria. We encircle a larger area within the pulmonary vein encircling incision so that we isolate a larger area from the contiguous atrium. Second, as we are closing the incision, we trim the atrial edges of those incisions so that when we get through, the patients no longer have a giant atrium. Whether or not over time they are going to enlarge again I do not know, but thus far that has not been a problem.

Dr. Engelman also asked a question regarding percentage of patients who have sinus rhythm upon leaving the operating room. That number has changed quite dramatically with the modification into the Maze-III procedure. If you had asked me that about the Maze I, I would say virtually none of them left the operating room in sinus rhythm, but now probably 80% to 90% leave in sinus rhythm. However, this sinus rhythm only lasts for approximately 1 or 2 days because of edema of the suture lines. The patients then develop a junctional rhythm that usually lasts for 5 or 6 days. It is during this junctional rhythm period that the residents and referring doctors get a bit nervous about wanting to implant permanent pacemakers. My advice is to just wait it out and the sinus rhythm will return.

Finally, Dr. Kron asked about contraindications to this procedure. Poor left ventricular function is our major contraindication.

Our experience and that of others has also been poor in patients with HOCM and we do not operate on those patients if they have a resting or inducible gradient across the aortic valve. However, it may now be time to re-evaluate that position in relation to patients with HOCM.

Virtually all 12 of the patients who have had recurrences had the Maze procedure performed as a redo operation, meaning that we had to modify the position of the atriotomies at the time of surgery. Therefore, unless a patient is actively embolizing from a demonstrable clot in the left atrium that cannot be controlled with anticoagulation or unless the patient has to have mitral valve surgery, we do not perform the Maze as a redo operation anymore.

Dr. Kron also asked a question regarding whether or not ev-

erybody with atrial fibrillation who is having a mitral valve operation should have a Maze procedure. Probably most of the people should. The Mayo Clinic group has documented that if a patient has atrial fibrillation for less than 3 months before the time of mitral valve replacement or repair, 80% will convert back to sinus rhythm postoperatively. If the atrial fibrillation is present more than 6 to 12 months preoperatively, the vast majority of those people will not convert after surgery.

In our practice now, if a patient has had atrial fibrillation for more than 6 months preoperatively, they almost invariably get the Maze procedure in conjunction with their mitral valve repair or replacement. If they have had it for less than 6 months and are in very good shape with good ventricles and so on, and it is an easy mitral valve repair, then we might perform the Maze in some of them as well. However, if the patient is quite sick, it is just a matter of surgical judgment.