

## Editorial

## Surgery for atrial fibrillation

A self confessed "former" arrhythmia surgeon has recently written that "the golden era of arrhythmia surgery for supraventricular arrhythmias has passed".<sup>1</sup> He rightly attributes the end of this era (which lasted only 20 years from the first description of surgical ablation of an accessory pathway) to the advent of catheter ablation and to the development of safer energy sources and better catheters. He also hopes that catheterisation techniques will be developed that will supersede recently described surgical operations to prevent atrial fibrillation.<sup>1</sup>

Surgery directed specifically at atrial fibrillation (rather than at its cause—for example, mitral valve disease) was initially aimed at interrupting atrioventricular (AV) conduction and thus controlling the ventricular response.<sup>2</sup> AV node ablation is now more commonly performed using percutaneous catheterisation techniques; and surgery for AV node ablation is performed either in conjunction with other surgery—for example, mitral valve replacement—or as a last resort.

More recently, specific operations for the treatment of atrial fibrillation refractory to medical treatment have been described. These operations are alternatives to AV node ablation with permanent ventricular pacing.

**The corridor operation**

Guiraudon devised the corridor operation, which isolates an atrial corridor consisting of the sinus node area, the AV nodal junction, and the connecting right atrial mass (fig 1).<sup>3-5</sup> This is designed to preserve sinus node function and hence physiological control of heart rate.

Two series of patients treated with the corridor operation have been described. Leitch *et al*<sup>3</sup> reported their results in nine patients. One patient required reoperation for early recurrence of atrial fibrillation. At postoperative electrophysiological study the corridor was shown to be electrically isolated from the atria in eight of nine; one patient had a junctional rhythm in the corridor connected to the AV node and so to the ventricles, one had atrial tachycardia, and one had atrial fibrillation/flutter. Sinus node function was abnormal in all, and pacemakers were implanted in four. Two have had late atrial arrhythmias.

Defauw *et al*<sup>4</sup> and van Hemel *et al*<sup>5</sup> described 36 patients, with permanent success in 24 (67%). Nine (25%), however, required repeat operation, which failed in five. Paroxysmal atrial arrhythmias occurred in the corridor in six of the 27 deemed successful (22%). Five patients in whom the second operation also failed subsequently underwent His bundle ablation with rate responsive ventricular pacing. Five patients with sinus node dysfunction also received pacemakers. Thus 28% required pacing. One patient had an early postoperative stroke and a second had a stroke 4 months later. During long-term follow up (mean 41 months) six of 31 had

attacks of atrial flutter requiring antiarrhythmic drugs.

So far, nine (31%) of 29 patients undergoing the corridor operation have required early reoperation for recurrent arrhythmias. Atrial arrhythmias may also recur later; they were seen in at least eight (22%) of 45. Postoperatively, sinus node dysfunction is common and permanent pacing may be required (in 32%). Atrial transport is not restored, and atrial thrombus and embolism presumably remain risks.

**The maze operation**

Pierce and Sobel described the maze operation as a "brilliant advance in surgery".<sup>6</sup> It was introduced and advocated by Cox *et al*.<sup>7</sup> The operation was designed to interrupt all potential reentrant circuits, while maintaining AV synchrony, so preserving both physiological control of heart rate and atrial contraction and thus reducing the risks of thrombosis and embolism.<sup>7</sup>

Cox and his colleagues have clearly described the rationale for and evolution of this surgical technique.<sup>8,9</sup> Both atria are precisely incised so that the impulse can

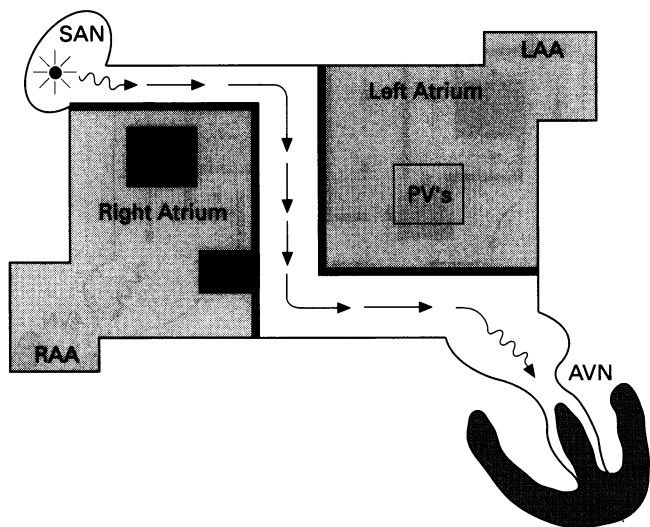
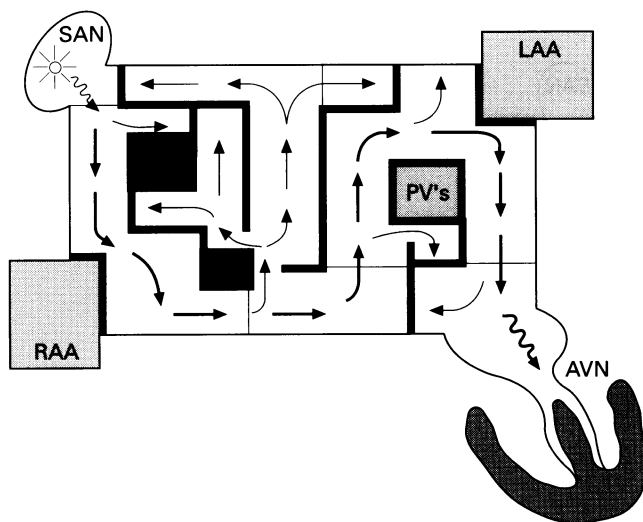


Figure 1 Schematic representation of the results of the corridor procedure for the surgical treatment of atrial fibrillation. Technically speaking, a sinus rhythm may follow this procedure in that the sinus node impulse drives the ventricles. However, because of loss of both right atrial and left atrial synchrony with the respective ventricles, the haemodynamic abnormalities associated with atrial fibrillation are not improved. In addition, the vulnerability to the development of left atrial thrombi is not alleviated. AVN, atrioventricular node; LAA, left atrial appendage; PV, pulmonary veins; RAA, right atrial appendage; SAN, sinoatrial node. Reproduced with the permission of the *Journal of Thoracic and Cardiovascular Surgery*.<sup>7</sup>

still propagate from the sinoatrial node to the atrioventricular node after surgical repair of the several incisions, and so that the atrial mass in continuity is insufficient to maintain atrial fibrillation (fig 2). Results have been reported in 75 patients from the St Louis group to date.<sup>7,10-13</sup> Their early experience has been reported extensively.<sup>7,10-12</sup> The mean cardiopulmonary bypass time in those not undergoing concomitant surgery was 184 (range 130–256) minutes with a mean aortic cross clamp time of 69 (50–102) minutes.<sup>13</sup> There was one operative death among the first 75 patients. Serious postoperative morbidity occurred, particularly in those who had undergone previous cardiac surgery and included postoperative biventricular assist and intra-aortic balloon pumping in one, re-exploration for bleeding in 7%, pancreatitis in 4%, and cerebrovascular embolism in 4% (transient ischaemic attacks in 3%). During the first three months after surgery, 47% of the patients had either atrial flutter or fibrillation. Forty percent of the patients who had been followed up for three months or more required permanent pacemakers postoperatively. Of these, 17/26 (65%), a surprisingly high proportion, had been shown by preoperative electrophysiological studies to have sinus node dysfunction, five already had pacemakers, and four were said to have sustained damage to the sinus node intraoperatively. Atrial flutter could be induced three or more months postoperatively in 6%. Atrial flutter has occurred spontaneously in eight patients (12%) and atrial fibrillation had recurred in one patient. Seven patients (11%) were taking antiarrhythmic drugs for atrial arrhythmias more than three months after operation.

Preservation of atrial transport function was demonstrated by echocardiography and by Doppler studies both early and late.<sup>7,12-14</sup>

The Cleveland Clinic experience was described by McCarthy *et al.*<sup>15-17</sup> Fourteen patients underwent surgery: one patient had a perioperative stroke and one patient



**Figure 2** Maze procedure for atrial fibrillation. Because atrial fibrillation is characterised by the presence of multiple macroreentrant circuits that are fleeting in nature and can occur anywhere in the atria, a surgical procedure based on the principle of a maze was developed. Both atrial appendages are excised and the pulmonary veins are isolated. Appropriately placed atrial incisions not only interrupt the conduction routes of the most common reentrant circuits, but they also direct the sinus impulse from the SA node to the AV node along a specified route. The entire atrial myocardium (except for the atrial appendages and pulmonary veins) is electrically activated by providing for multiple blind alleys off the main conduction route between the SA node and the AV node, thereby preserving atrial transport function postoperatively. See fig 1 for abbreviations. Reproduced with the permission of the *Journal of Thoracic and Cardiovascular Surgery*.<sup>7</sup>

died within 30 days. Mean cardiopulmonary bypass time in all patients was 143 (117–172) minutes and mean aortic cross clamp time was 69 (47–98) minutes (mean 139 and 66 minutes without concomitant surgery). The initial postoperative rhythm was junctional, but sinus rhythm resumed. Two patients had perioperative sick sinus syndrome and received dual chamber rate responsive pacing. Six patients (43%) had postoperative atrial fibrillation and others had transient atrial fibrillation or flutter. There was no recurrence of atrial fibrillation after the first three months.<sup>17</sup> Other reports describe few<sup>18</sup> or individual patients.<sup>19-21</sup>

An interesting complication recognised by both groups<sup>10,13,17</sup> is the tendency to retain excessive fluid postoperatively. Cox *et al.*<sup>10,13</sup> reported pulmonary oedema in 71% of their early patients and attributed this to a decrease in atrial natriuretic peptide. Subsequently, routine administration of spironolactone prevented pulmonary oedema.<sup>13</sup> McCarthy *et al.* reported pleural effusions or peripheral oedema or both in 36% of their patients.<sup>17</sup>

So far, 95 patients undergoing the maze operation have been described. Operative mortality is 2% and postoperative morbidity is not uncommon. Atrial arrhythmias occur in about half in the first three postoperative months, but seem to cease after this. Sinus node dysfunction is common and permanent pacing may be required in up to half. Atrial transport is restored, and atrial thrombus and embolism are thought not to remain risks. Cox *et al.* no longer routinely use anticoagulation postoperatively.<sup>13</sup>

Postoperative sinus node dysfunction has been studied in detail in dogs by McLoughlin *et al.*<sup>22</sup> Sinus node dysfunction occurred acutely in all 17 animals after the maze operation. Sinus node function tended to return to normal in the succeeding 6 months, but remained abnormal compared with preoperative values. Postoperative arrhythmias were observed in nine (53%) of 17 and were mainly bradycardias. Only five (29%) of 17 survived between 90 and 180 days. No reason was given for this.

Cox's original technique is already being modified,<sup>11,17,18,21,23</sup> specifically in an attempt to minimise surgical trauma to the sinus node,<sup>17</sup> to preserve its blood supply,<sup>17</sup> and to reduce potential technical difficulties.<sup>18</sup>

Thus surgery specifically directed at atrial fibrillation has been devised and described. Neither Guiraudon's corridor operation<sup>3-5</sup> nor Cox's maze operation<sup>7-14,16,23,24</sup> have been performed in many patients or by many surgeons. The results described are necessarily preliminary and short term. There is concern about high morbidity, particularly after the maze operation; need for a second operation, particularly after the corridor operation (although this perhaps represents relative inexperience); and recurrent atrial arrhythmias, not necessarily fibrillation. The high requirement for pacing postoperatively is also a concern: it is due in part to preoperative sinus node dysfunction, to intraoperative trauma, and to devascularisation of the sinus node, and in part to surgical failure and subsequent treatment by AV node or His bundle ablation. The maze operation has been described with great enthusiasm<sup>6</sup>—it has the advantage over the corridor operation that it may preserve atrial transport<sup>24</sup>; the price, however, is sinus node dysfunction and permanent pacing in about half the patients. It is reassuring that a second group has achieved similar results.<sup>15-17</sup> However, until the presumed long-term benefits of such surgery, including preservation of atrial transport and lack of requirement for anticoagulation, can be demonstrated it might be argued that His bundle ablation and permanent rate responsive pacing has similar results, lower morbidity,

and costs less. It remains to be seen whether the maze operation is in fact a surgical cure for medically refractory atrial fibrillation,<sup>13</sup> or whether it becomes, as has already been advocated, a prophylactic procedure in those predisposed to atrial fibrillation.<sup>23</sup> If it is a cure, other “former” arrhythmia surgeons may also find a new role.<sup>1 19 20</sup>

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