Experimental Production of AV Block

Comparison between Electrical Ablation and a New Catheter Technique Using Anhydrous Alcohol

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SUMMARY

Production of chronic complete atrioventricular block (CAVB) was attempted by two closed-chest methods in dogs. One is a modified electrical ablation method (EA), and the other is a new catheter technique to inject anhydrous alcohol into the subendocardium of the AV junction (alcohol method). EA was performed in 6 dogs and the alcohol method in 10 dogs. Chronic CAVB was produced in 5 dogs (83%) by EA and in 7 dogs (70%) by the alcohol method. Escape ventricular rhythm with narrow QRS morphology was found in 4 dogs (80%) with EA, and in 3 dogs (43%) with the alcohol method. Except for transient supraventricular tachyarrhythmias which occurred immediately after EA, both methods were performed without complication. EA had a higher success rate in producing CAVB on the narrow QRS of the escape ventricular rhythm occurred more frequently than reported in the literature and than in the case of the alcohol method. The alcohol method, though, may be superior to EA for human applications because it does not require general anesthesia.

Additional Indexing Words:
Atrioventricular block Electrical ablation New catheter technique Anhydrous alcohol

An AV block is produced in cardiovascular studies that require control of heart rate, and may also be used in treatment of intractable supraventricular tachyarrhythmias in patients. Three open-chest methods have been reported: Direct interruption of His bundle, cryosurgery or injection of sclerosing materials to the AV junction. In addition, there are closed-chest methods, including a special catheter technique or electrical ablation (EA). The latter methods are attractive because thoracotomy can be

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avoided. Recently, EA has been applied clinically to control intractable supraventricular tachyarrhythmias and excellent results have been reported.\textsuperscript{7,8} Since an artificial pacemaker is implanted after production of AV block, the escape ventricular rhythm should be fast and should occur regularly to avoid accidental cardiac arrest from a possible pacemaker malfunction. The transvenous catheter technique injects sclerosing materials, and is thought to be superior to EA because it does not require general anesthesia in humans and is not complicated by tachyarrhythmias. However, this method has not been available because of the potent risk of major complications.\textsuperscript{4,6} Therefore, EA has been modified to obtain CAVB with a faster and more regular escape ventricular rhythm, and a new catheter technique was used to inject sclerosing material into the AV junction to produce CAVB. This paper compares the results of the two methods.

**METHODS**

1) Electrical ablation (EA)

Six mongrel dogs weighing 6 to 10 Kg were used. They were anesthetized with intravenous pentobarbital. A standard 7 Fr woven dacron intracardiac electrode catheter with 1 cm interelectrode distances (USCI) was inserted through the right femoral vein. The electrode catheter was advanced into the region of the His bundle, while two bipolar electrograms were monitored simultaneously (1 from the distal pair and 1 from the proximal pair of electrodes). Intracardiac electrograms (50 to 500 Hz bandpass) were monitored.

![Diagram](image)

**Fig. 1.** A: Schema for electrical ablation (see text). S=switching box; D=defibrillator; P=paddle placed on the back; 1=distal electrode; 2=central electrode; 3=proximal electrode. B: Representative His bundle electrogram. HBE\textsubscript{p} and HBE\textsubscript{d} indicate HBE recorded from the proximal and the distal pairs of electrodes, respectively.
recorded on a photorecorder at a paper speed of 25 or 100 mm/sec simultaneously with the body surface ECG (lead II). The catheter was positioned at the tricuspid ring, and pulled back to the most atrial site where His bundle electrograms are best recorded from two bipolar leads. The A wave was as large as the V wave (Fig. 1). Then, a direct current of 200 to 300 Ws was delivered from a standard defibrillator between the middle electrode and a paddle placed on the back. A switch box allowed the catheter electrode to record intracardiac electrograms first, and subsequently, to deliver DC shock. ECGs were monitored continuously for 30 min after the procedure. If AV conduction returned, additional shocks were delivered until CAVB was obtained.

2) A new catheter technique (alcohol method)

Catheter: A specially designed catheter composed of an insulated outer stainless tube (o.d=2 mm, length=30 cm) and an insulated inner stainless needle, was devised (Fig. 2). The outer surface of the tube was insulated with silicon. The tip of the catheter was curved gently to touch cardiac structures easily. A bipolar electrogram can be recorded from the tip of the needle and a non-insulated part of the tube at a site 5 mm proximal to the tip. The inner needle can be advanced 5 mm from the tip of the catheter by manipulating the handle at the other end of the catheter.

Procedures: 10 mongrel dogs weighing 6 to 10 Kg under intravenous pentobarbital anesthesia were used. The catheter was introduced from the right external jugular vein and advanced into the right atrium. Intracardiac electrograms were recorded in the same manner for EA. At the low right
atrium, where large His electrograms were clearly recorded (the A wave was as large as the V wave), the needle was advanced through the tip of the catheter and embedded in the endocardium. If the tip of the catheter is properly placed in the right atrium, the atrial potentials were distorted to a monophasic configuration when the endocardium was penetrated. This finding is important to avoid disruption of the tricuspid valve and not to damage the interventricular septum. Two tenth ml of 2% lidocaine with contrast medium (76% urografin) was injected through the needle into subendocardium, which was instantaneously followed by CAVB (Fig. 3). The site of the injection into the subendocardium was confirmed fluoroscopically. Anhydrous alcohol was then injected (0.2ml). Next, the catheter was advanced to the right ventricular apex for the purpose of pacing. For 30 min, dogs were observed to determine whether AV conduction returned. Dogs were observed chronically, and were kept under pacing with an endocardial electrode and external generator after CAVB. Three weeks after the procedure, they were sacrificed and subjected to macroscopic examination. During the follow-up period, electrograms were recorded in awake states. The ventricular cycle length of the escape rhythm was obtained the day after the procedure. Data are presented as the mean ± SD. Statistical analysis was performed by t-tests. Differences were considered to be significant if a p value was less than 0.05.

Results

1) Electrical ablation (Table I)
In all dogs His bundle electrograms were clearly recorded (Fig. 1B).
Table I. Summary of Experimental Production of AV Block

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Preadblation QRS (msec)</th>
<th>Delivered energy (Ws)</th>
<th>Result</th>
<th>Escape rhythm</th>
<th>Junctional tachycardia</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>QRS (msec)</td>
<td>CL (msec)</td>
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<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>70</td>
<td>300 + 300</td>
<td>CAVB</td>
<td>70</td>
<td>970</td>
</tr>
<tr>
<td>2</td>
<td>65</td>
<td>300</td>
<td>CAVB</td>
<td>100</td>
<td>1820</td>
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<td>-</td>
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<td>65 ± 17</td>
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<td>CAVB</td>
<td>60</td>
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<td>10</td>
<td>50</td>
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<tr>
<td>mean ± SD</td>
<td>53 ± 4</td>
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<td>69 ± 17</td>
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</tbody>
</table>

Escape rhythm was recorded on the day after production of AV block. Junctional tachycardia appeared immediately after electrocoagulation. Case 1 in group 1 received 2 shocks. QRS = QRS width; CAVB = complete AV block; 1-AVB = first degree AV block; CL = cycle length.

Fig. 4. Representative ECG tracing by electrical ablation. Immediately after delivery of 200Ws, a complete AV block was obtained. Lead is II.
Chronic CAVB was obtained by electrocoagulation at 300 Ws in 3 dogs, and at 200 Ws in the other 3 dogs. In 1 dog, AV conduction returned within a few minutes, but with an additional 300 Ws current, chronic CAVB was obtained. The ventricular escape rhythm occurred immediately after production of AV block, and it was so slow that the dogs had to be paced (Fig. 4). In 4 dogs, junctional tachycardias were observed immediately after electrolytic lesions were completed, however, they disappeared within a minute without treatment (Fig. 5). In 1 dog, CAVB with a narrow QRS ventricular escape rhythm was produced, but AV conduction recovered on the following day. In this dog, first degree intra-His bundle block was observed (Fig. 6). The other 5 dogs (83%) showed chronic CAVB during the 3rd week with ventricular escape rhythm, the average cycle length of which was 1049 msec. In 4 dogs, the QRS width of the escape rhythm was narrow and the average cycle

![Image](A before shock)  
**B** immediately after delivery of 200 Ws  
---  
1000 msec

**Fig. 5.** Representative ECG tracing after electrical ablation. **A:** normal AV conduction. **B:** Supraventricular tachycardia occurring immediately after ablation. Lead is II.

**HBE one day after delivery of 300 Ws (case 3)**

![Image](A V)

**Fig. 6.** HBE 1 day after electrical ablation (see text).
length was 830 msec. In the remaining dog, the QRS width of the escape rhythm was wide, with a cycle length of 1820 msec. No dog died during the follow-up period of 3 weeks. Macroscopic examination showed that the tricuspid ring, the interatrial septum and the interventricular septum were not damaged. There was a redness of 5 mm in diameter on the endocardial surface of the AV junction in the dog which was used for another experiment on the 3rd day. A single catheter was used for all dogs without disruption.

2) Alcohol injection method (Table I)

In 1 dog, His bundle electrograms could not be recorded as clearly as in the other 9 dogs (Fig. 3) so the animal was excluded from the study. In 7 of 9 dogs (70%) chronic CAVB was obtained (Fig. 7), however, in 2 other dogs the complete AV block was transient, or AV conduction returned within 15 min of the procedure. In 7 dogs with a complete AV block, the average cycle length of the escape rhythm was 1404 msec. Three dogs showed an escape rhythm with a narrow QRS and 4 other dogs showed a wide QRS. The cycle length of the escape rhythm was shorter in the former (1121 msec) than that in the latter group (1687 msec) (Fig. 8). In 1 of 4 dogs with a wide QRS, the cycle length of the escape ventricular rhythm could not be measured because the heart was paced within 20 sec. The ventricular cycle length was not significantly different from the EA group (Fig. 8).

Macroscopic examination during the 3rd week after the procedure showed no apparent lesion at the AV junction, the tricuspid valve, the interatrial septum or the interventricular septum. When the interval of the escape rhythm was analyzed in all the dogs from both methods, the ventricular cycle length was 1020 msec.

Fig. 7. A complete AV block persisted during the follow-up period after electrical ablation. RR = ventricular cycle length.
Fig. 8. Ventricular cycle length 1 day after production of AV block. Left panel shows the ventricular cycle length after electrical and alcohol ablations (see text). The right panel shows the relation between cycle length and QRS width.

Cycle length was shorter in dogs with narrow QRS (970 msec) than in those with wide QRS (1720 msec) (p<0.01).

**DISCUSSION**

A closed-chest method of production of complete AV block has obvious advantages over open-chest methods (such as direct interruption or cryosurgery) because thoracotomy is not necessary. The occurrence of a stable escape ventricular rhythm is also a desirable feature, given the possibility of pacemaker failure. The present study indicates that the rate of the escape rhythm with narrow QRS was faster and more stable than that with wide QRS (Fig. 8) for either the electrical or alcohol ablation methods. In reports of electrical ablation, the current was delivered from the distal electrode which recorded His bundle electrograms and large atrial activity. In these cases, QRS width of the escape rhythm was wide in 44% to 100% of cases.5)–8) However, in the present modified electrical ablation, DC current was applied through the central wire of a tripolar electrode. The QRS escape rhythm was narrow in 80% of the animals, with regular rhythm with an average cycle length of 830 msec (Table I). Thus, the site of ablation must be more proximal than the site of other workers, and the current needed was comparable to the conventional method using the distal electrode. A delivery of DC current to the distal electrode is empirically thought to be superior to the proximal electrode because the distal electrode should be more closely applied to the AV junction and because the current density from the distal electrode may be the largest.7),8) The use of the central electrode in the present study...
resulted in a more desirable escape rhythm with a success rate equal to that reported by other workers.

Although supraventricular tachyarrhythmias frequently occurred immediately after current passage in this study, it was infrequent in other reports of electrical ablation. It is also not clear why supraventricular tachycardia occurred. The site of the electrode may be related to the occurrence of supraventricular tachyarrhythmias. The tachyarrhythmias terminated spontaneously without hemodynamic deterioration. Although thoracotomy is not necessary, electrical ablation requires general anesthesia, which has infrequent complications such as hypotension and ventricular tachycardias.8)

Another transvenous method, the local injection of a sclerosing material (formalin) using a special cannula, was first attempted by Babotai and Brownlee.4) In this method, 40% formalin was injected into the site where unipolar His bundle electrograms were recorded. Beazell et al reported a result of an electrocoagulation method in which the tip of the catheter was guided using fluoroscopical landmarks and 30 to 40 Ws was delivered through a stiff transseptal needle until complete AV block could be obtained.8) Although this method had a high success rate for production of CAVB, it is neither reliable nor safe. In this study, CAVB was induced by the injection of alcohol into the AV junction. There are some advantages of the alcohol method. First, the alcohol method needs only a local anesthesia when applied to humans. Second, prior to the injection of anhydrous alcohol, the injection site is confirmed by a test injection of lidocaine; the injection of lidocaine is followed by a complete, transient AV block if the site is appropriate.9) Third, the alcohol method was not complicated by tachyarrhythmias, and fourth, a small dose of anhydrous alcohol is thought to be harmless in the systemic circulation. Although there are several advantages, the success rate in production of AV block was 70% and the occurrence of a narrow QRS escape rhythm was less frequent than with electrical ablation. To improve this method, the tip of the catheter should have variable curves according to cardiac size. Anhydrous alcohol may be weak as a sclerosing material but it is non-toxic systemically. In addition, the needle advanced from the tip may enter a more distal site in the His bundle resulting in a wide QRS escape rhythm.

Experiments to produce AV block by these two methods can be performed easily without major complications. Furthermore, no apparent damage to cardiac structures was recognized by macroscopic examination 3 weeks after the procedure. Electrical ablation has gained popularity in the treatment of supraventricular tachyarrhythmias. Identification of the proper site for DC current application or the injection of anhydrous alcohol is essential for the success of either method. Production of AV block should be under-
taken as a last resort for the control of supraventricular tachyarrhythmias, since the patient has to be artificially paced for life. This is different from catheter electrical ablation of the focus of ventricular tachycardia, which needs no pacemaker therapy. However, it can be an emergency tool to treat patients with fatal atrial flutter and 1:1 AV conduction.11)

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