Experimental Study

Tensile Force of Pacing Lead Extraction

A Comparison between Tined Type and Screw-in Type

Shigeru AMITANI, MD, Hiroshi SOHARA, MD,
Mitsuro KUROSE, MD, Kenkichi MIYAHARA, MD,
Kazuhiro MISUMI,* DVM,
and Hiroshi SAKAMOTO,* DVM

SUMMARY

Three months after implantation of endocardial pacing leads in 10 mongrel dogs, the tensile forces needed to remove 5 tined type and 5 screw-in type leads were compared experimentally.

Mean maximum tensile force was 291 ± 174 g with the screw-in type and 1174 ± 369 g with the tined type ($p < 0.01$). Histopathologically, no changes suggesting any myocardial damage due to lead extraction were recognized in cases where screw-in type leads were used. These results support the clinical feasibility of safe and easy manual retraction of infected pacing leads of the screw-in type. (Jpn Heart J 1996; 37: 495-501)

Key words: Pacemaker Infected pacing lead Manual retraction

GENERALLY, it is not necessary to remove an endocardial pacing lead once implanted, but when a patient develops an infection with bacteremia, it is extremely hard to cure the infection unless not only the generator but also the pacing lead is removed.¹⁾ There are many reports available concerning the method of infected pacing lead extraction.^{2,3)} However, there remain some problems with reliability, security or economy.

Endocardial pacing leads presently used can be broadly divided into two types, the tined type and the screw-in type. As the latter easily causes an increase of the pacing threshold,⁴⁾ the former is generally used. Recently, a new steroid-eluting screw-in type lead has been developed.⁵⁾ Structurally, this screw-in type lead is designed to be less resistant than the tined type in the axial direction after fixation to the endocardium. Thus extraction after chronic usage should be easier and safer compared with the tined type.^{6,7)} No previous studies have examined whether the screw-in type has an advantage in extraction or not. Thus, the tensile

From the Division of Cardiology, Shinkyo Hospital, Kagoshima, and *Laboratory of Veterinary Surgery, Department of Veterinary Medicine, Faculty of Agriculture, Kagoshima University, Kagoshima, Japan.

Address for correspondence: Shigeru Amitani, MD, Division of Cardiology, Shinkyo Hospital, 3-41-1 Usuki, Kagoshima 890, Japan.

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force required for lead extraction was compared between the tined type and screw-in type pacing lead using mongrel dogs.

MATERIALS AND METHODS

Endocardial pacing leads were implanted in 10 adult mongrel dogs (7–21 kg, mean 12.5 kg). The screw-in type (model 4057M, Medtronic Inc., Minneapolis, MN, USA) was used in 5 dogs and the tined type in the remaining five (models 4012S and 4024, Medtronic Inc. in 2 dogs, model 431–04, Intermedics Inc., Freeport, TX, USA in 3 dogs). After subcutaneous injection of atropine at 0.05 mg/kg, endotracheal intubation was performed under intravenous anesthesia with thiopental sodium at 25 mg/kg and then equipped with the Harvard respirator to ventilate with oxygen and enflurane. The left external jugular vein was incised and an endocardial pacing lead was inserted toward the right ventricular apex under fluoroscopy. The pacing lead was fixed at a position where the optimal pacing threshold was obtained. After mounting the insulating cap the distal end of the pacing lead was buried subcutaneously and closed by suture. Penicillin was administered at 30,000 unit/kg for 7 days after the operation.

Three months after the operation, tensile forces required for lead extraction were measured under the same anesthesia as the first operation. The distal end of the pacing lead was taken out and the fixing ligature on the jugular vein was cut. The distal end was then connected to the tensiometer (LT/50K, Shinko Tsushin Kogyo Co. Zushi, Japan) via piano wire, and the maximum tensile force needed for removal of the pacing lead was measured using a strain gauge (DS6/MTH, Shinko Tsushin Kogyo Co.), and recorded on a polygraph (Figure 1). Removal

Figure 1. Experimental schema.

was carried out under fluoroscopy. In cases with the screw-in type lead, it was performed after retraction of the screw tip.

Immediately after the removal test, the animal was sacrificed with intravenous administration of magnesium sulfate and the heart extracted. The anterior free wall of the right ventricle was vertically incised toward the apex, and the right ventricular endocardium on top of the pacing lead was observed. Histological observation was performed with hematoxylin-eosin staining after fixation in 10% buffered formalin.

The unpaired t-test was employed for statistical tests, and the level of significance was fixed to be below 5%.

RESULTS

Mean maximum tensile force needed for removal of the pacing lead was 291 ± 174 g with the screw-in type, and 1174 ± 369 g with the tined type ($p < 0.01$) (Table). Because of insufficient retraction of the screw tip on removal, the maximum tensile forces required in two dogs (Nos. 7 and 8) were larger than those needed in the other three dogs, and yet they were smaller than those needed in the five dogs with tined type leads.

Macroscopic findings of the right ventricular endocardium after removal of the pacing lead were as follows: In the screw-in type, the cylindrical tissue corresponding to the tip of the lead was observed (Figure 2-a). In the tined type, cylindrical tissue that had been encircling the pacing lead was not found in the endocardium (Figure 2-b), and the presence of residual torn tissue was confirmed around the tip of the lead (Figure 3). Histopathologically, proliferative connective tissue was observed at the tip of the pacing lead both with the tined type and the screw-in type. The surface of the endocardial side was flat with the tined type, but V-shaped with the screw-in type. In neither case, however, was change sug-

Table. Types of Pacing Leads and Tensile Force for Lead Extraction

Dog No.	Lead model	Tensile force (g)	Mean $\pm$ SD
1	Medtronic 4012S	1300	
2	Medtronic 4024	1720	
3	Tined Intermedics 431-04	1150	1174 ± 369
4	Intermedics 431-04	750	
5	Intermedics 431-04	950	
6	Medtronic 4057M	182	
7	Medtronic 4057M	400*	
8	Screw-in Medtronic 4057M	545*	291 ± 174
9	Medtronic 4057M	180	
10	Medtronic 4057M	150	

*Incomplete retraction

Figure 2. Macroscopic findings of right ventricular endocardium after removal of pacing leads. a) The cylindrical tissue (arrow) corresponding to the tip of the lead was observed with the screw-in type. b) With the tined type, however, the cylindrical tissue probably encircling the pacing lead was not found and torn tissue remained on the endocardium (arrow).

Figure 3. Macroscopic finding of removed pacing lead. Residual torn tissue was confirmed around the tip of the tined type lead.

Figure 4. Histopathological findings of right ventricular endocardium (a: tined type, b: screw-in type) ($\times 25$). Proliferative connective tissue was observed corresponding to the tip of the pacing lead. No changes suggesting any myocardial damage due to lead extraction were confirmed in either case. C = connective tissue; M = myocardium.

gesting any myocardial damage due to lead extraction recognized (Figure 4).

DISCUSSION

It is not easy to remove the endocardial pacing lead when time has elapsed after implantation of a permanent pacemaker.^{1,6)} Various methods for lead extraction in cases of an infected pacemaker lead have been reported, including using continuous traction,²⁾ snare wires or retrieval baskets, and recently, removal kits.³⁾ These methods, however, are not always safe and appropriate. When a lead cannot be removed by these methods, open heart surgery may be required.⁸⁾ Mizuno et al stated that even with the removal kit, 3 cases out of 5 are unsuccessful, and open heart surgery was needed in 3 cases of 7 with lead infection.⁹⁾

Between April 1981 and December 1995 a total of 610 (439 first implantations, and 171 replacements) transvenous pacemakers were implanted at our institution. Of 485 pacing leads used in 439 first implantations (227 tined types and 258 screw-in types), removal of the pacing lead after chronic use was required in 5 cases because of infection and other reasons. One case out of 3 tined type leads was removed using the removal kit, while the others needed open heart surgery. On the other hand, both cases using the screw-in type leads were successfully removed by manual retraction. Apparently, as seen in our clinical experience, the screw-in type lead requires less tensile force for removal compared to the tined type. To our knowledge, however, neither experimental nor clinical studies on this important problem have been reported.

The results of this study have shown that the tensile force needed for removal of the screw-in type lead is less than that needed for the tined type, probably no more than one-fourth. Thus, our results show the clinical feasibility of manual retraction of screw-in type leads. Furthermore, the lower possibility of myocardial penetration after lead extraction is indicated according to the histological findings.

The screw-in type lead has been thought to increase the pacing threshold more easily than the tined type,⁴⁾ and to have a higher risk of myocardial penetration.¹⁰⁾ Therefore, tined type leads are applied more frequently. Even after chronic use, however, the screw-in type lead provides extremely favorable and stable pacing conditions.⁶⁾ Its disadvantage of raising the pacing threshold acutely is being corrected by using a steroid-eluting screw-in type lead.⁵⁾ Taking into consideration the above data and the results of this study, the screw-in type lead should be selected to prepare for the possibility of infected lead extraction,⁶⁾ excluding those special cases associated with thinning of the right ventricular wall such as occur in dilated cardiomyopathy and old myocardial infarction.

In this study, experiments relating to atrial pacing were not carried out. The tensile force needed for retraction of an atrial pacing lead is expected to be same as that required for a ventricular lead. However, as the anatomical structure and thickness of the atrial and ventricular walls are different, histopathological changes seen at the tip of the pacing lead after removal might be different between the atrium and the ventricle. Moreover, the tensile forces required in longer-term cases were not investigated. Therefore, further study is recommended.

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