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Findings of Transesophageal Echocardiographic Images in Placing the Coronary Sinus Perfusion Catheter

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ABSTRACT

In retrograde cardioplegia (RCP), some difficulty is occasionally encountered when inserting a catheter into the coronary sinus (CS). Although the usefulness of transesophageal echocardiography (TEE) for guiding the cannulation procedures has been previously reported by other authors, we have obtained additional findings by TEE monitoring of eleven patients during placement of the CS catheter. The diameter of the CS ranged from 5.5 to 10.7 mm, indicating that it was large enough for the CS catheter to be inserted and that the resistance at insertion was not due to narrow CS. The precise time for inserting the catheter, for which myocardial protection is delayed, ranged from 8 to 376 seconds, with an average of 98 seconds. Dislodgement of the catheter was found in two cases. In case of difficult cannulation, the catheter tip was found to be pushing the right atrial wall adjacent to the CS orifice or alternatively it entered the middle cardiac vein which had a common atrial orifice with the CS in this particular case. We found that the knowing the following technical problems helps appropriate monitoring: the catheter tip becomes unclear when it is not perpendicular to the ultrasonic beam, when surgeon's fingers are placed behind the heart, or when the blood is entirely exsanguinated. Finally we present the possibility of employing images of overflow out of CS during RCP infusion, detected by TEE, as an index of efficient perfusion at the interventricular septum.

Key words: *Transesophageal echocardiography, Cardioplegia, Retrograde perfusion*

Retrograde cardioplegia (RCP) is one of the established techniques for myocardial protection during cardiopulmonary bypass[2,3]. A specially-made perfusion catheter is inserted into the coronary sinus (CS) either by opening the right atrium (RA) or just by puncturing the RA wall and advancing the catheter into the CS in a blind manner. In the former, a successful insertion can be visually confirmed but the procedures are time consuming and additional tourniquets around the superior and inferior vena cava are needed. In the latter method, it is sometimes difficult to insert the catheter tip into the CS or to confirm successful placement by manual palpation in redo cases. In neither situation can one recognize the intracardiac events such as penetration of the coronary vein or an escape of the catheter out of CS during manipulation of the heart. Aldea et al[1] reported on the usefulness of transesophageal echocardiography (TEE) for directing the CS catheter in the blind technique. In this paper, we report on the mechanisms of unsuccessful cannulation detected by TEE and the images of blood flow during RCP which can be used as an index of efficient perfusion during RCP.

SUBJECTS AND METHODS

The cannulation procedures were examined with TEE in eleven consecutive cases with RCP: 7 men and 4 women with the ages ranging from 40 to 74 years old. The operative procedures were aortic valve replacement in 7 patients and repair of aortic aneurysm in four. Written informed consent was obtained from every patient and the examination was carried out as part of routine intraoperative monitoring.

After induction of anesthesia, a 5MHz single-plane transesophageal probe (UST-5225V-5, Aloka, Tokyo) was inserted and connected to an echocardiographic system (SSD-860, Aloka, Tokyo). The images were recorded with a VHS video taperecorder (AG-6300, Panasonic, Osaka) for later analysis. After the patient was put on bypass and hypothermia was obtained, an RCP catheter (RC-014-MIB, Research Medical Inc., Midvale, USA) was inserted into the CS through a purse string suture placed on the RA wall, while the CS was visualized with TEE during the insertion procedures (Fig. 1) in the manner previously described[7]. Successful placement of the catheter in the CS was confirmed both by the surgeon's palpation and the TEE findings, i.e., a catheter image depicted at the great cardiac vein at the atrioventricular groove in the three-chamber view (Fig. 2). When the insertion was unsuccessful, its cause was examined with TEE.

From the recorded images, we measured the diameter of the CS orifice together with the time lapse from start of cannulation to confirmation of successful placement of catheter with TEE.

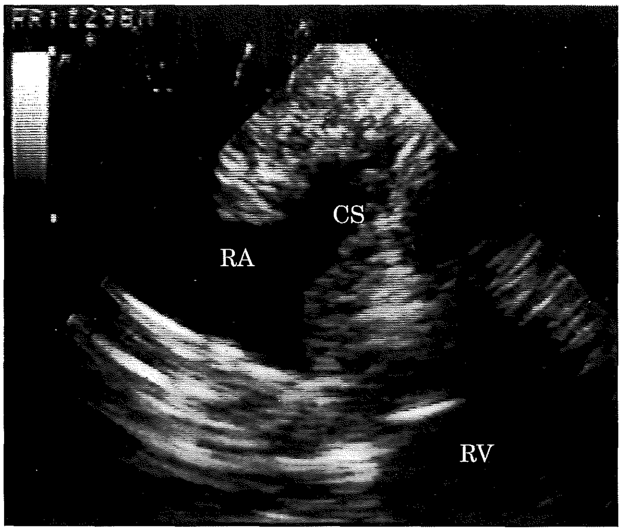

Fig. 1. TEE view of coronary sinus around the atrial orifice. CS: coronary sinus; RA: right atrium; RV: right ventricle.

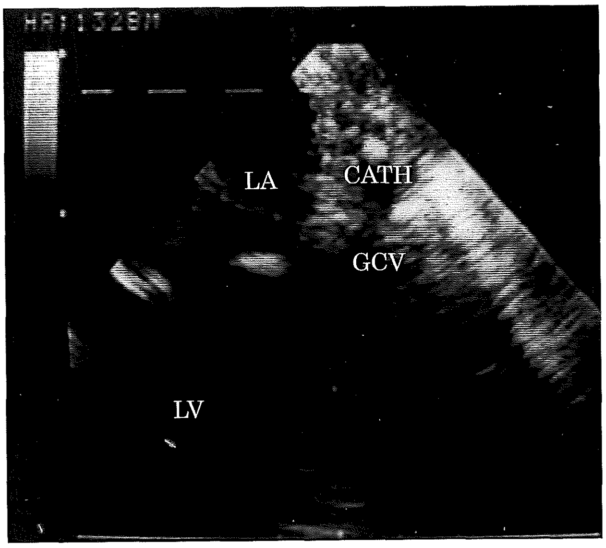

Fig. 2. Catheter tip in the great cardiac vein at the atrioventricular groove in the three-chamber view. LA: left atrium; LV: left ventricle; GCV: great cardiac vein; CATH: catheter.

Table 1. Results

Case #	Time for Insertion	Cause of difficult insertion	Diameter (mm)
1	6'16"	left side of orifice	10.6
	0'50"	left side of orifice	
2	1'39"	out of scanning plane	6.0
	2'45"	left side of orifice	
3	0'15"	–	7.8
4	3'11"	out of scanning plane	8.1
5	0'08"	–	9.7
6	2'15"	out of scanning plane	6.1
7	1'40"	entry to a branch	5.5*
8	0'29"	–	7.0
9	0'50"	out of scanning plane	6.6
10	0'25"	–	10.7
11	0'27"	–	8.6
Mean	1'38"		7.88

"Left side of orifice": the catheter tip pushed the RA wall on the left side of the coronary orifice; "Out of scanning plane": the catheter tip was not in the scanning plane of the coronary sinus; "Entry to a branch": the catheter tip entered a small branch of CS; Diameter: the diameter of coronary sinus; *: diameter of common orifice was 9.8 mm.

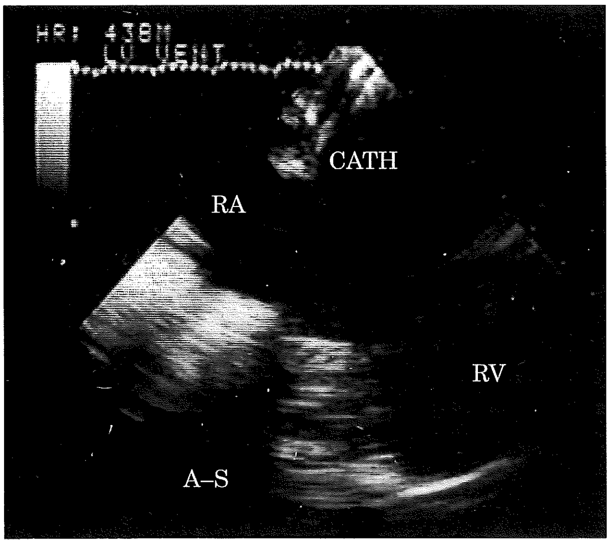

Fig. 3. Catheter in the coronary sinus near the atrial orifice, depicted as a pair of echogenic lines, accompanied by acoustic shadow.
A-S: Acoustic shadow.

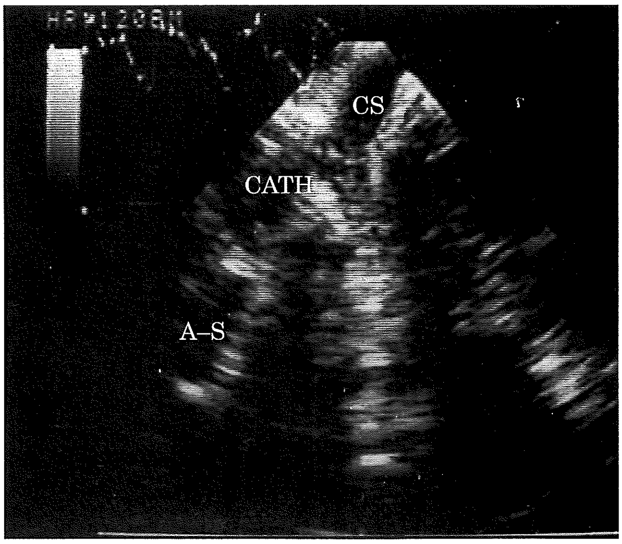

Fig. 4. Catheter tip pressing the left side wall of orifice of coronary sinus.

RESULTS

The results are listed in Table 1. No complication related to the insertion of RCP catheter was encountered. The catheter was properly placed in the CS in every case. Additional attempts were needed in cases #1 and #2, in these cases, the inserted catheter was accidentally pulled out during the subsequent procedures. This event was confirmed both by the surgeon's palpation and by the TEE findings, i.e., a loss of catheter image in the CS.

The diameter of the CS orifice was 7.9 mm on average, ranging from 5.5 to 10.7 mm. This was large enough for the placement of a CS catheter (4.7 mm in diameter). The catheter in the RA and CS was depicted as a line of thick strong echo, accompanied by acoustic shadow. The catheter portion in the RA was directed toward the CS orifice, nearly perpendicular to the RA wall (Fig. 3), but was not always visualized.

In the overall 13 attempts of insertion, the time for cannulation ranged from 8 seconds to 376 seconds with an average of 98 seconds. In 8 of 13 attempts, it took longer than 30 seconds. Reasons for difficult insertion included: 1) The catheter tip was close to the CS orifice but out of the scanning plane for CS in 4 attempts; 2) The catheter pushed the RA wall beside the orifice of CS in 3 attempts; 3) The catheter entered the middle cardiac vein in one attempt. In the first situation, the catheter did not appear on the screen but the RA wall moved as the surgeon manipulated the catheter. In the second situation, strong catheter echo was seen on the left side wall of the CS orifice and moved according to the surgeon's manipulation (Fig. 4).

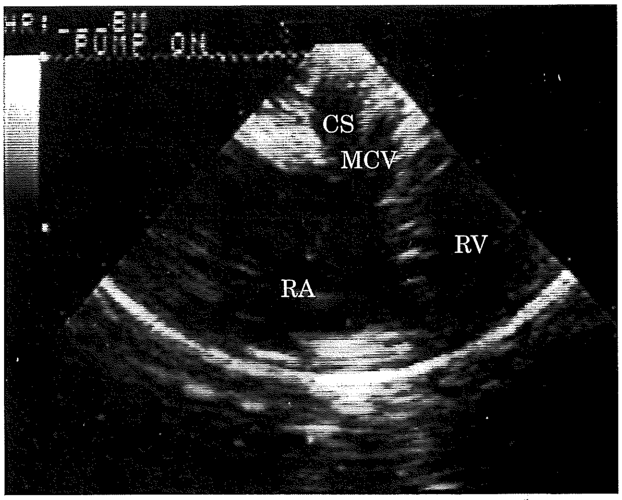

Fig. 5. Middle cardiac vein arising from the coronary sinus near its atrial orifice. MCV: middle cardiac vein.

In case #7, the CS and middle cardiac vein formed a common atrial orifice (Fig. 5). The catheter tended to enter the middle cardiac vein several times (Fig. 6), then entered the CS. In this particular case, the diameter of the common orifice was 9.8 mm, while that of CS was as small as 5.5mm.

During the retrograde infusion of cardioplegic solution, the flow toward the orifice was detected around the catheter in the CS or spontaneous echo contrast appeared in the RA near the CS orifice (Fig. 7).

DISCUSSION

A CS catheter is often inserted with the RA

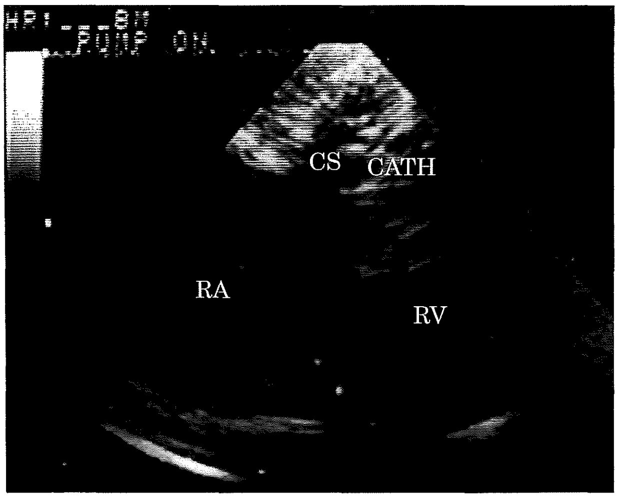

Fig. 6. Catheter tip entering the middle cardiac vein, depicted as a strong echo in the middle cardiac vein as shown in Fig. 5.

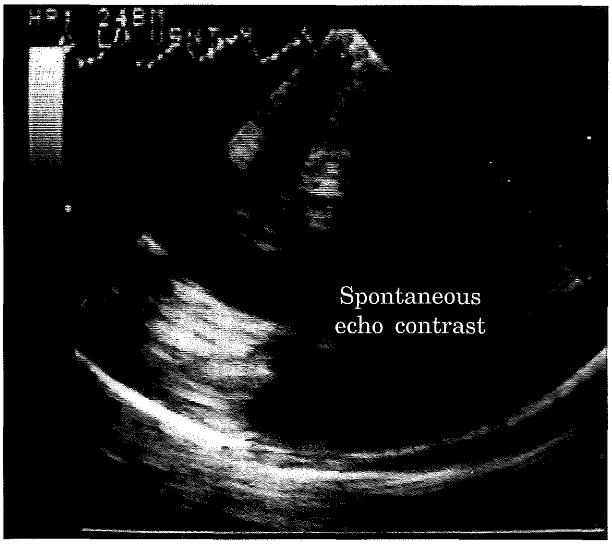

Fig. 7. Spontaneous echo contrast around the atrial orifice of coronary sinus, indicating a backflow from the coronary sinus during retrograde cardioplegia.

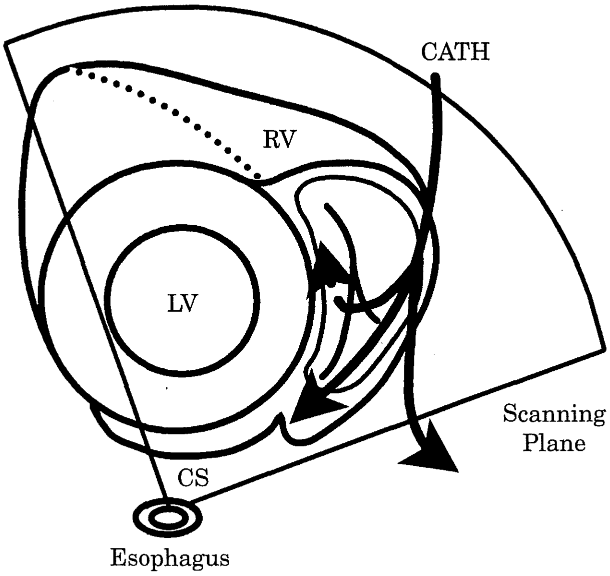

Fig. 8. Possible mechanisms of difficult insertion of catheter into the coronary sinus.
The catheter may push the right atrial wall close to the orifice or escape toward the right atrium or ventricle. The sector shows the scanning plane of TEE.

wall incised because of frequent difficulty in entering the CS. We have used a blind puncture technique through a purse string suture on the RA wall, with TEE monitoring, and have found that the CS and catheter in the RA is distinctly visualized, as Aldea et al[1] reported.

In the above-mentioned report it was stated that TEE detected cannula misdirection into the inferior vena cava or RV. However, we found the catheter tip pushing the RA wall adjacent to the CS orifice in 3 cases. This finding was not mentioned in their report. A possible mechanism is schematically illustrated in Fig. 8. As the catheter is inserted into the RA and advances along the lateral and posterior RA wall toward the orifice of CS, it may not smoothly enter the CS but push the RA wall adjacent to the CS orifice as well as escape toward the inferior vena cava or RV. An anterior traction of the lateral RA wall might be helpful for straightening the course of the catheter along the posterior RA wall toward the CS orifice in the case where TEE is not available. However this maneuver is often limited in the redo cases because of adhesion. Aldea et al[1] reported that more than half of CS cannulation failures without TEE occurred in reoperations. TEE is advantageous in guiding the catheter into the CS in such cases.

Another reason for the unsuccessful cannulation in this report was the common orifice of CS and middle cardiac vein. This was not mentioned in Aldea's report. If the operator forcefully advances the catheter in the branch vein against the resistance, the cardiac vein can be lacerated or penetrated. Higami et al[4] monitored the pressure at the catheter tip during retrograde infusion and obtained an unusually high pressure in 7.5% of cases and mentioned that this might be caused by an accidental entry of the catheter into a small branch. When TEE is not available, the anomaly of CS orifice cannot be found without inspecting the CS by elevating the ventricular apex. Preoperative coronary angiography may be helpful for checking the branches of CS near its atrial orifice, although it was not feasible in case #7 of acute aortic dissection.

In addition to the placement of the catheter, an accidental dislodging of the catheter can be diagnosed as a loss of catheter image in the CS, as we experienced in two cases. In order to avoid the ineffective cardioplegia, we check the catheter whenever the retrograde perfusion pressure is unusually low or high, and rule out the dislodgement of the catheter and an entry into a branch vein.

There are several pitfalls in the use of TEE. The images are tomographic and the object out of the scanning plane is not visualized. Frequent manipulation of the TEE probe is needed in a single plane TEE. A biplane or multiplane TEE might be advantageous. When the catheter is directed obliquely to the ultrasonic beam, it cannot be visualized because the ultrasound is reflected elsewhere. Visualization of intracardiac events is disturbed when the surgeon's finger is placed behind the heart or the ventricular apex is elevated. The RA and CS are not visualized distinctly when the blood is exsanguinated. Pooling a certain amount of blood in the RA makes it easier to monitor the insertion procedures.

We usually advance the catheter tip deeply beyond the orifice of the middle cardiac vein which perfuses the inferior interventricular septum. This is because obstruction of the vein with the inflated balloon can lead to poor myocardial protection in this region[6]. Because the overflow into the RA was detected during RCP infusion, in spite of adequate inflation of the balloon at the catheter tip, the cardioplegic solution appears to perfuse the middle cardiac vein region through the anastomosis between the coronary vein networks[5] and drain to the coronary sinus. However, further investigation is mandatory in order to clarify the efficiency of perfusing the inferior interventricular septum using this method.

In conclusion, TEE facilitates a proper and secure placement of CS, and assures the presence of catheter in the CS thereafter, by noninvasively providing real-time information.

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