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Comparative Study of Cerebral Protection during Surgery of Thoracic Aortic Aneurysm

Taijiro SUEDA[1)], Takayuki NOMIMURA[1)], Tetsuya KAGAWA[1)], Satoru MORITA[1)], Saiho HAYASHI[1)], Kazumasa ORIHASHI[1)], Hiroo SHIKATA[1)], Gou RYUU[1)], Yoshiharu HAMANAKA[1)], Yuichiro MATSUURA[1)], Yasushi KAWAUE[2)], Keiichi KANEHIRO[3)] and Hiroshi ISHIHARA[4)]

1) First Department of Surgery, Hiroshima University School of Medicine, 1-2-3 Kasumi, Minami-ku, Hiroshima 734, Japan
2) Department of Cardiovascular Surgery, Hiroshima General Hospital, Hiroshima
3) Department of Cardiovascular Surgery, Chugoku-Rosai Hospital, Kure
4) Department of Cardiovascular Surgery, Asa Munincipal Hospital, Hiroshima

ABSTRACT

During the past 5 years, 30 cases of thoracic aortic aneurysm were treated. Selective cerebral perfusion (SCP) and retrograde cerebral perfusion (RCP) were conducted for cerebral protection during aortic cross clamping. SCP was carried out in 5 cases of dissecting aneurysm (all Stanford type A, including a case of AAE) and 3 cases of arch aneurysm. RCP was conducted in 5 cases of dissecting aneurysm (4 Stanford type A, 1 Stanford type B with retrograde dissection) and 2 cases of aortic arch aneurysm. The mean cerebral perfusion time of SCP exceeded that of RCP (89 ± 26 min in SCP versus 61 ± 33 min in RCP $p<0.05$). The hospital mortality rate was 38 % (SCP) and 29% (RCP). Neurological complications were prolonged unconsciousness (1/8 in SCP, 1/7 in RCP) and transient paralysis (0/8 in SCP, 1/7 in RCP). Although the mechanism for the cerebral protective effect of RCP is unknown, this perfusion method is easy and safe, requiring little time for ascending and/or arch aortic reconstruction.

Key words: *Ascending and arch aortic aneurysm, Selective cerebral perfusion, Retrograde cerebral perfusion*

The surgical management of thoracic aortic aneurysm requires temporary adjuncts to prevent ischemia of the brain during aortic arch repair. For cerebral protection, deep hypothermic arrest or selective cerebral perfusion is usually suitable[2)]. But in deep hypothermic arrest, there is a limit to the period of arrest of the cerebral circulation, and therefore the operation must be conducted rapidly[1)]. Selective cerebral perfusion (SCP) is ideal for cerebral protection, and replacement of the total aortic arch is possible since cerebral circulation can be maintained during surgery of aortic arch aneurysm. However, selective cannulation to the carotid arteries is necessary for SCP and causes cerebral embolism in some cases. The encircling of the carotid arteries is often difficult in cases of aortic arch aneurysm[3)]. Recently, retrograde cerebral perfusion (RCP)[5)] has been found an easy method for cerebral protection during operation of ascending and/or arch aortic aneurysm. The authors used this method for thoracic aortic aneurysm. Results using SCP and RCP for thoracic aortic aneurysm are compared in this paper.

MATERIALS AND METHODS

During the past 5 years, we operated on 30 cases of thoracic aortic aneurysm. The patients consisted of 16 cases of ascending and/or arch aortic aneurysm and 14 cases of descending aortic aneurysm. Various methods were used to avoid ischemia of the brain and visceral organs during aortic cross clamping (Table 1). For cerebral protection, SCP or RCP was carried out in 15 patients. SCP consists of maintaining a separate circulation to the brain and body by means of individual roller pumps. Blood temperature is usually quite hypothermic (mean 19°C rectal temperature). The cannulation method of RCP is the same as that in open heart surgery. After inducing deep hypothermia in the normal manner of extracorporeal circulation, a small amount of hypothermic blood is retrogradely perfused through the superior venous cannulae (Fig. 1). During RCP, perfusion to the body is arrested (circulatory arrest). The cerebral blood flow is regulated by independent roller pumps and controlled to 480ml/min of the mean flow in the SCP group and 280 ml/min in the RCP group.

Address for correspondance: Dr. Taijiro SUEDA

Table 1. Supportive method of thoracic aortic aneurysm

Site	Supportive method	Number of patients	Total number
Ascending and arch aortic aneurysm	Selective cerebral perfusion	8 (3)	
	Retrograde cerebral perfusion	6 (1)	16 (4)
	Hypothermic perfusion	1	
	Left heart bypass	1	
Descending Aortic Aneurysm	Left heart bypass	11 (2)	
	Retrograde cerebral perfusion	1 (1)	14 (4)
	Deep hypothermia	1 (1)	
	Temporary shunt	1	
			30 (8)

( ) Hospital Death

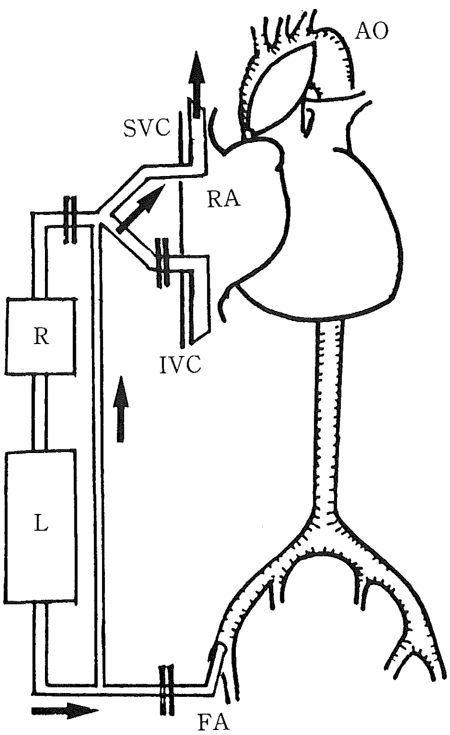

Fig. 1. Perfusion circuit during retrograde cerebral perfusion

After induction of deep hypothermia by extracorporeal circulation, a small amount of oxygenated blood is retrogradely perfused into the brain through the venous cannulae toward the superior vena cavae (→). During retrograde cerebral perfusion, perfusion toward visceral organs except the brain is arrested (hypothermic circulatory arrest) and the aortic clamp is released during repair of aneurysm (open aortic technique).

AO: aorta, SVC: superior vena cavae, IVC: inferior vena cavae, RA: right atrium, FA: femoral artery, R: reservoir, L: artificial lung, →: blood flow, ||: clamping place during RCP

Right temporal arterial pressure is measured during SCP and maintained from 40 to 60 mmHg. The venous pressure of SVC is monitored during RCP and controlled at 20 to 25 mmHg. The patients comprised 8 cases of SCP and 7 cases of RCP. Among the cases in which SCP was emploid, there were 5 cases of dissecting aneurysm (Stanford A) and 3 cases of arch aortic aneurysm. The patients, 6 men and 2 women in SCP, ranged in age from 45 to 78 years. (mean age, 62 years). The operative procedures were replacement of the ascending and/or arch aorta in all patients, including a case of coronary arterial reconstruction by the Bentall procedure (Table 2). RCP was carried out in 7 cases, 5 men and 2 women, 45 to 82 years in age, mean age 68 years. The operative procedure was patch closure in one patient and replacement of the ascending aorta and/or arch aorta (Table 3) in the others.

RESULTS

The mean extracorporeal circulation time of cerebral perfusion was 275 ± 187 min in SCP and 302 ± 138 min in RCP and that for aortic cross clamping was 118 ± 24 min in SCP and 117 ± 76 min in RCP. The cerebral perfusion time in both methods was significantly different (89 ± 26 min in SCP versus 61 ± 33 min in RCP. $p<0.05$) (Fig. 2). The same neurological complications were encountered in both methods. A patient in the SCP group showed conscious disturbance after operation but recovered 3 days after surgery. Electroencephalography showed normal waves in 6 of 8 cases. There was one case of transient ischemia with hemiplegia and one of conscious disturbance in RCP. The case showing prolonged unconsciousness had a type B dissecting aneurysm with retrograde dissection toward the arch aorta. Two hours were required to replace the descending aorta under retrograde cerebral perfusion. Unconsciouness continued during the postoperative period and electroencephalography showed a burst and suppression (Fig. 3). Electroencephalography indicated suppression of cerebral activity due to cerebral damage caused by prolonged RCP. Electroencephalography showed small α waves 3 days after surgery, indicating that cerebral activity was still vigorous after RCP for 2 hours. Another case with transient

Table 2. Cases supported by selective cerebral perfusion

Type of aneurysm	Age	Sex	Site of repl.	CPT (min)	Result
Dissecting (A)	54	M	Ascending aorta	65	Well
Distal Arch	78	F	Distal arch	120	Death by bleeding
Distal Arch	65	M	Total arch	110	Well
Distal Arch	74	M	Total arch	110	Death by LOS
Dissecting (A)	65	M	Descending aorta	105	Death by bleeding
Dissecting (A)	61	M	Proximal arch	82	Well
Dissecting (A)	55	M	Proximal arch	82	Well
AAE	45	F	Bentall	45	Well
				89	

CPT: Cerebral perfusion time
repl.: replacement
AAE: Annulo aortic ectasia
(A): Stanford A type
LOS: low cardiac output syndrome

Table 3. Cases supported by retrograde cerebral perfusion

Type of aneurysm	Age	Sex	Procedure	Time of R.C.P. (min)	Result
Distal arch	65	M	Patch closure	65	Well
Dissecting (B)*	45	M	R. of desc. aorta	120	Dead, Renalfailure
Dissecting (A)	67	M	R. of asc. aorta	33	Well
Arch aorta	82	M	R. of arch	40	Well
Dissecting (A)	72	F	Bentall	47	Dead, LOS
Dissecting (A)	65	F	R. of asc. aorta	90	Well
Dissecting (A)	72	M	R. of asc. aorta	30	Well
				mean 61	

*Retrograde dissect in to arch
R.C.P: Retrograde cerebral perfusion
(A): Stanford (A), (B): Stanford (B)
R.: replacement

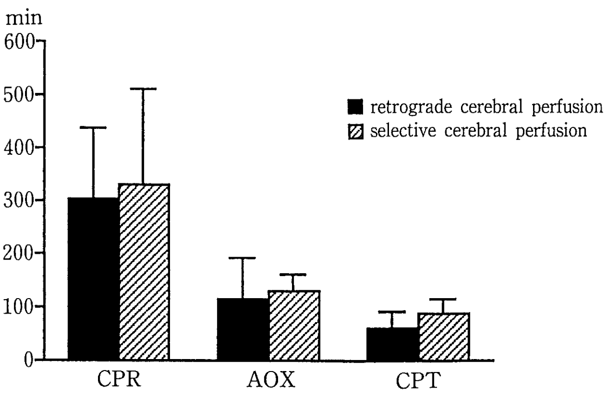

Fig. 2. Circulation time for cerebral perfusion

CPB: cardiopulmonary bypass
AOX: aortic cross clamping
CPT: cerebral perfusion time

ischemic damage after surgery recovered completely from cerebral damage. The early mortality rate was 38 % in SCP and 29 % in RCP. No late death was encountered in either group (Table 4).

DISCUSSION

Surgical treatment of ascending and/or arch aortic aneurysm is very difficult in cardiovascular surgery, the mortality rate being reported 20 to 35%[1-3]. One problem is neurological complications, such as cerebral embolism and conscious disturbance. Neurological complications are often fatal and cerebral protection is of the utmost important. Deep hypothermia with circulatory arrest is one cerebral protective method during arch aortic operation, but the time is strictly limited for circulatory arrest with deep hypothermia and a period longer than 30 min[1,2] may be dangerous. Selective cerebral perfusion makes possible optimal cerebral perfusion during aortic cross clamping and provides cerebral protection for a period of more than 3 hours. However, this method requires complicated procedures such as the encircling and clamping of the arch tributaries[3]. Recently, RCP was developed by Ueda et al[5]. They used RCP in aortic arch surgery with a low mortality rate (20%). RCP is a simple method for cerebral perfusion and cannulation to the carotid arteries, and clamping of the carotid tributaries is not required. Although the efficacy of this method in cerebral protection is not

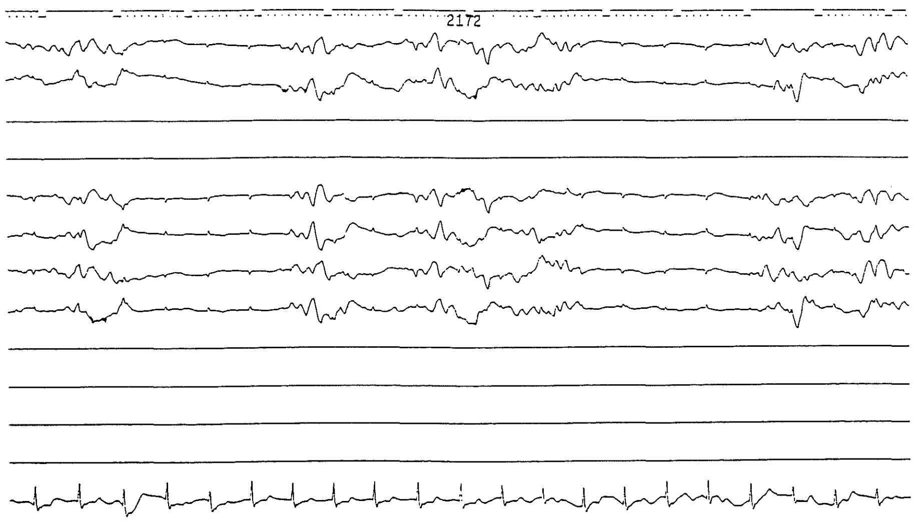

Fig. 3. Postoperative EEG of a case after prolonged RCP

Electroencephalography after prolonged retrograde cerebral perfusion (120 min) showed waves of burst and suppression. These indicate suppression of cerebral activity due to aneshesia and/or retrograde cerebral perfusion.

Table 4. Complications and results of cerebral perfusion

		Neurological complication		Early and late motality	
Selective cerebral perfusion	n=8	Delayed awakeness	1/8	Early mortality	3/8 (38%)
				Late mortality	0/8 (0%)
Retrograde cerebral perfusion	n=7	Transient ischemia	1/7	Early mortality	2/7 (29%)
		Delayed awakeness	1/7	Late mortality	0/7 (0%)

clear, it appears safe for a period of no more than 2 hours. The authors have used RCP as a temporary adjunct for arch aortic operation since Feb 1991 and also as a technique of open aortic anastomosis for arch aortic replacement. Under deep hypothermic circulatory arrest, the distal open aortic technique facilitates repair of arch aortic aneurysm without clamping the distal arch[4]. During hypothermic circulatory arrest, cerebral perfusion is maintained by low flow retrograde perfusion through the superior vena cavous cannulae in RCP. This procedure is easier than SCP and replacement of the aortic arch can be done quickly. But whether cerebral protection in this method is adequate is doubtful. Perfusion of the cerebral cortex may not be physiological in RCP and an animal experiment to examine the cerebral protective effect in RCP has been started. Further study of electrophysiological functions of the brain such as somatosensory evoked potential (SEP) may be necessary. During hypothermia, electroenceophalography is not reliable as a monitor of cerebral ischemia. Since SEP is a method for evaluating cerebral ischemia during hypothermia and hypoperfusion, it may become a monitor of cerebral function during RCP. RCP may have a superior effect for cerebral protection compared to hypothermic circulatory arrest. But there is a time limitation of approximately 2 hours in RCP. Although our limited experience indicates the operative results of RCP to be superior to those of SCP, we must continue careful study of RCP for its improvement. There is also a problem of renal dysfunction due to circulatory arrest to the body in RCP. We encountered a case of renal failure through prolonged circulatory arrest and modified this method for hypothermic low flow perfusion to the visceral organs in addition to RCP. Although the operative results of thoracic aortic aneurysm still remain unsatisfactory, an improved supportive method for cerebral perfusion should lead to better operative results.

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