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Advantages of subclavian artery perfusion for repair of acute type A dissection☆

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Abstract

Objective: Arterial perfusion through the right subclavian artery is proposed to avoid intraoperative malperfusion during repair of acute type A dissection. This study evaluated the clinical and neurological outcome of patients undergoing surgery of acute aortic type A dissection following subclavian arterial cannulation compared to femoral artery approach. **Methods**: From 1/97 to 1/03, 122 consecutive patients underwent surgery for acute type A aortic dissection. Subclavian cannulation was performed in 62 versus femoral cannulation in 60 patients. Clinical characteristics in both groups were similar. Mean age was 61 years (SD ± 14 years, 72% male) and mean follow-up was 3 years (±2 years). Patient outcome was assessed as the prevalence of clinical complications, especially neurological deficits, mortality at 30 days, perioperative morbidity and time of body temperature cooling and analyzed by nominal logistic regression analysis for odds ratio calculation. **Results**: Arterial subclavian cannulation was successfully performed without any occurrence of malperfusion in all cases. Patients undergoing subclavian cannulation showed an odds ratio of 1.98 (95% CI 1.15–3.51; $P = 0.0057$) for an improved neurological outcome compared to patients undergoing femoral cannulation. Re-exploration rate for postoperative bleeding was significantly reduced in the subclavian group ($P < 0.0001$), as well as occurrence of myocardial infarction ($P < 0.0001$) and duration for body temperature cooling ($P = 0.004$). The 30-day mortality of patients with femoral cannulation was significantly higher compared to patients with subclavian artery cannulation (24 versus 8%; $P = 0.0179$). **Conclusions**: Arterial perfusion through the right subclavian artery provides an excellent approach for repair of acute type A dissection with optimized arterial perfusion body perfusion and allows for antegrade cerebral perfusion during circulatory arrest. The technique is safe and results in a significantly improved clinical and especially neurological outcome.

Keywords: Aortic dissection; Ascending aorta; Right subclavian artery cannulation; Neurology

1. Introduction:

Surgery for acute type A aortic dissection is still associated with an increased risk of perioperative mortality and morbidity due to potential malperfusion of visceral organs and the brain.

It is common practice to institute cardiopulmonary bypass via femoral cannulation and to protect the brain via retrograde cerebral perfusion through the superior vena cava (SVC). However, retrograde blood flow in the aorta may lead to an extension of the dissection as well as to severe embolization due to the atherosclerotic aortic wall.

To overcome this predicament several groups have begun to cannulate the right subclavian or axillary artery. This technique allows a continuous antegrade body perfusion and additionally a selective cerebral antegrade perfusion during circulatory arrest thus preventing organ malperfusion and neurologic damage [1–3].

The aim of this study was to assess patient outcome during in-hospital stay in a larger series suffering from acute type A dissection comparing antegrade selective cerebral perfusion with retrograde femoral perfusion, respectively.

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We devote special emphasis to incidence of in-hospital death, adverse neurologic outcome, bleeding complications and body temperature.

2. Patients and methods

Between January 1997 and January 2003, 122 consecutive patients underwent surgery for acute Type A dissection in the University Hospital Zurich. Until June 2000 institution of cardiopulmonary bypass was achieved via femoral artery and right atrium cannulation (femoral group, FG) with consecutive cerebral retrograde perfusion of the patient. In that period first experiences with subclavian artery cannulation were gathered in cases other than Type A dissection, however, with severely calcified aorta. Beginning with June 2000 the cannulation protocol was changed in favor of antegrade perfusion via the right subclavian artery (subclavian group, SG). As depicted in Table 1 there were 62 patients in the SG group, whereas 60 patients could be enrolled in the FG group. Altogether 35 women (28.6%) and 87 men (71.3%) with a mean age of 59.9 ± 15 years (range 24–83 years) were operated. Preoperative ejection fraction (EF) was similar (54.58 ± 4.89% (SG) versus 55.45 ± 8.19% (FG), $P =$ ns) in both groups. Comorbidities are depicted in Table 2. All patients were treated on an emergency basis after diagnosis was established based on transesophageal echocardiography, computer tomography in most cases and recent medical history. Of the 122 patients 37 (30.3%) had signs of hemodynamically significant pericardial effusion, 23/122 (18.8%) showed severe aortic regurgitation. These findings were confirmed intraoperatively without exception.

The site of the primary tear was located echocardiographically. In the SG 30 intimal lesions (48.4%) were found in the ascending aorta and 12 (19.4%) in the arch. In 8 patients (12.9%) multiple tears could be detected. In the FG localization was the ascending aorta in 35 patients (58.3%) and the arch in 10 (16.6%). In 12 patients (19.9%) multiple tears were visible. In a total of 14 cases (11.4%) no tears could be found in the ascending aorta or arch, assuming a retrograde dissection starting at the descending aorta. The extension of dissection was limited to the ascending aorta in 15 patients (24.1%) of the SG, and in 23 patients (38.3%) of the FG. Dissection extended to the descending aorta in 33 cases (53.2%) in the SG group and in 25 cases (41.6%) in the FG group.

Table 1
Demographic data

Parameters	Subclavian group (SG)	Femoral group (FG)
Number of patients (*n*)	62	60
Male gender (%)	42 (68)	45 (75)
Female gender (%)	20 (32)	15 (25)
Age (mean age ± SD) in years	63.7 ± 13	62.1 ± 16
Age (range) in years	35–83	34–82

Table 2
Comorbidities at time of admission, *n* (%)

Comorbidities	Subclavian group (CS)	Femoral group (FG)	*P*-value
Hypertension	37 (60)	39 (65)	ns
Aortic regurgitation	10 (16)	13 (21)	ns
Pericardial effusion	29 (46.7)	28 (46.7)	ns
Pericardial tamponade	17 (28)	20 (32)	ns
Visceral malperfusion	2 (3)	3 (5)	ns
Lower limb ischemia	16 (26)	18 (30)	ns
Ejection fraction (<30)	1 (2)	3 (5)	ns
Myocardial hypertrophy	37 (60)	39 (65)	ns
Ischemia (ST elevation)	3 (5)	4 (6)	ns

Due to the mainly rapidly deteriorating hemodynamics no preoperative angiography was performed, thus potential coronary artery disease (CAD) was merely assessed by ischaemic electrocardiogram (ECG) in 36/122 (29.5%) cases or medical history. The average interval between onset of symptoms and operation was 11.9 ± 5.5 h, with 11.3 ± 4.8 versus 12.6 ± 6 h in the SG and FG group, respectively ($P =$ ns).

Preoperative and postoperative neurologic status was categorized in 4 severities: asymptomatic, mild neurologic impairment (agitation, confusion, delirium with complete postoperative remission and negative CT-scan), moderate neurologic impairment (hemisensory loss, facial palsy) and severe neurologic impairment (e.g. stroke, positive CT-scan). Preoperative census showed no significant differences between the groups (Table 3).

All data were gathered by retrospective review of patient charts.

2.1. Surgical technique

Patients were placed supine and arterial pressure monitored via three arterial lines placed in both radial arteries and the left femoral artery. Rectal and nasal temperature probes were placed to control body and brain temperatures. Neurological monitoring was done with a bispectral index EEG (Aspect® Medical Systems, Leiden, The Netherlands) to indirectly control brain perfusion. Furthermore size and reaction of eyes were permanently controlled. The head was additionally cooled with topical ice-packages, 30 min prior to circulatory arrest. To control

Table 3
Preoperative neurologic impairment, *n* (%)

Severity	Subclavian group (SG)	Femoral group (FG)	*P*-value
Asymptomatic	37 (60)	31 (52)	ns
Mild	9 (15)	3 (5)	ns
Moderate	6 (9)	10 (17)	ns
Severe	10 (16)	16 (26)	ns

cardiac function and extent of dissection a transesophageal echocardiograph (TEE) was routinely installed.

Depending on clinical stability anaesthesia was induced with midazolan (0.1 mg/kg), fentanyl (10 μg/kg) and hypnomidate (0.2 mg/kg). Consecutively muscles were relaxated using esmerone (0.6 mg/kg). Anaesthesia was maintained with propofol and remifentanyl. No pharmacologic neuroprotective drugs were administered. Into the extracorporeal bypass 2 Mio. IU of Aprotinin was administered. An additional 2 Mio. IU was given via iv-line with another 500,000 IU/h operation time. pH balance was controlled by means of α-stat method.

2.1.1. Femoral cannulation

In cases of femoral cannulation, the right femoral artery was surgically exposed prior to sternotomy. After median sternotomy, systemic heparinization was administered and a venous single-two stage cannula inserted in the right atrium. For retrograde cerebral perfusion the superior vena cava was cannulated separately. During hypothermic circulatory arrest, this vessel was occluded proximally and perfused with a target flow of 500 ml/min under controlled pressure not exceeding 40 mmHg (20 °C). Myocardial protection was achieved by retrograde cold-blood cardioplegia via the sinus venosus. In addition, the left heart was vented through a transmitral catheter.

After decannulation, the arterial incision was closed with 6-0 Prolene single sutures.

2.1.2. Subclavian cannulation

Even in patients with no palpable or measurable pulse in the right radial artery, indicating a possible dissection of the right subclavian artery, the vessel was used for perfusion. Via a deltoideopectoral approach the artery was exposed: the skin incision runs from the lateral third of the clavicle to the junction of deltoid with pectoralis major muscle. Along the course of the cephalic vein, both muscles were separated and, in conjunction with the pectoralis minor muscle, retracted (Fig. 1). The artery was dissected without touching the brachial plexus. Consecutively the vessel was either directly cannulated in 26/62 patients (Sarns™,24F, Terumo®, USA) or via an 8 mm Dacron graft (Gelweave™, Terumo®, Belgium) that was end-to-side anastomosed to the artery with a 6-0 Prolene suture (36/62 patients). In cases of indirect graft cannulation, the artery was snared distally to the anastomosis to adjust the pressure in the right radial artery (approx. 50 mmHg) and thus to avoid a hyperperfusion syndrome of the right arm. Myocardial protection was achieved by retrograde cold-blood cardioplegia via the sinus venosus. In addition, the left heart was vented through a transmitral catheter. During hypothermic circulatory arrest the innominate artery as well as the left carotid artery were clamped and the brain antegrade perfused at a rate of 1000–1500 ml/min (20 °C). Backflow via the left subclavian artery was controlled by means of a Fogarty catheter (Baxter Health Care, USA) placed in the distal aortic arch or

Fig. 1. Exposure of the right subclavian artery. Retractors withdraw the pectoralis minor and major muscle as well as the deltoid muscle. Site of cannulation/anastomosis is indicated with a circle.

by an additional clamp. After decannulation the incision in the artery was closed with 7-0 Prolene sutures, or, in case of indirect cannulation, the graft resected at the level of anastomosis.

The standard operative technique at our institution for acute type A dissection encompasses glue-aortoplasty for aortic root reconstruction (gelatine-resorcinol-glutaraldehyde/formaldehyde, Trigon GmbH, Mönchengladbach, Germany) with concomitant supracoronary graft implantation and hemiarch replacement of the asc. aorta, composite graft replacement as well as valve sparing procedures described by Tirone David [4]. Details of our operation techniques have been previously described [5]. The extent of surgical repair is shown in Table 4. In cases of complete aortic arch repair en bloc techniques to reimplant the supraaortic vessels were used [6].

Table 4
Surgical techniques and procedures, *n* (%)

Technique	Subclavian group (SG)	Femoral group (FG)	*P*-value
SC	22 (36)	31 (52)	ns
SC, HA	24 (39)	12 (20)	ns
SC, AVR	1 (1)	2 (3)	ns
SC, HA, AVR	2 (3)	2 (3)	ns
CG	8 (13)	3 (5)	ns
CG, HA	5 (8)	8 (13)	ns
TD	0	2 (3)	ns

SC, supracoronary graft; HA, hemiarch replacement; AVR, aortic valve replacement; CG, composite valved graft; TD, Tirone David procedure.

All operations have been performed through a median sternotomy. Circulatory arrest was instituted in all patients with mean duration of antegrade cerebral perfusion of 23.38 ± 10.2 min versus retrograde cerebral perfusion of 23.53 ± 8.45 min ($P =$ ns) at a mean core temperature of 19.96 ± 3.47 °C. To prevent dissection of the coronary ostia, cardiac arrest had been achieved by mere retrograde infusion of high potassium cardioplegia with or without subsequent continuous infusion of cold blood. Average aortic crossclamp time was 85.02 ± 35.5 min with 82.03 ± 36.7 min in the SG group versus 88.15 ± 34.1 min in the FG group ($P =$ ns). Duration of extracorporeal circulation was 165.9 ± 62.2 min, with 175.83 ± 64.31 versus 155.64 ± 58.71 min in the SG and FG group, respectively ($P =$ ns).

2.2. Statistical analysis

Data of clinical baseline characteristics are reported as the frequency or mean ± SD by group and comparisons were calculated with unpaired *t*-test. Creatine kinase (CK) and lactate dehydrogenase concentrations had a skewed distribution, thus data are presented as median with 25 and 75% quartiles and comparisons were made with non-parametric Wilcoxon's rank sum test. Categorical variables were tested using the Pearson's χ^2-test. Logistic regression was used to examine the association between method of cannulation and neurological outcome. The odds ratio is presented with the corresponding 95% confidence interval. A P-value <0.05 was selected for statistical significance for all analyses. We used the statistical software package JMP™ 5.0.1 (SAS Campus Drive, Cary, NC 27513, USA).

3. Results

There was 1/122 (0.8%) perioperative death within the FG group. The overall in-hospital mortality rate of 15.6% (19 of 122) was 8.6% (5 of 62) and 23.3% (14 of 60) for SG and FG, respectively ($P = 0.0179$). Causes of death in the SG group were multiorgan failure ($n = 2$), intestinal ischemia ($n = 1$), heart failure ($n = 1$), hypoxic encephalopathy ($n = 1$), whereas in the FG group bleeding during operation ($n = 1$), intestinal ischemia ($n = 3$), multiorgan failure ($n = 5$), acute myocardial infarction ($n = 1$), heart failure ($n = 2$) and hypoxic encephalopathy ($n = 2$) lead to death. Extension of dissection among the deaths in the SG group reached to cerebral vessels ($n = 1$), ascending aorta ($n = 1$) and infrarenal abdominal aorta ($n = 4$). They were treated with supracoronary grafts ($n = 2$), supracoronary grafts with hemiarch replacement ($n = 2$) as well as a composite graft ($n = 1$). Extension of dissection among the deaths in the FG group reached to cerebral vessels ($n = 3$), ascending aorta ($n = 5$) and infrarenal aorta ($n = 6$). Surgical treatment consisted of supracoronary grafts ($n = 5$) and supracoronary grafts with hemiarch replacement ($n = 9$). Further procedures and surgical techniques are depicted in Table 4.

Prolonged postoperative neurologic dysfunction, which was assessed in all surviving patients by means of adequate examinations, was seen in 9/103 alive patients (8.7%) with 1/57 (1.75%) in the SG and 8/46 (17.4%) in the FG group. The SG group encountered hemiplegia (1/1), the FG group hemiplegia (4/8), tetraplegia (1/8), hypoxic encephalopathy (2/8) and paraplegia (1/8).

Transient postoperative neurologic damage occurred in 25/103 (24.3%) surviving patients with 11/57 (19.2%) in the SG and 14/46 (30.4%) in the FG group. In addition, no neurologic postoperative impairment could be found in 69/103 (67%) patients with 45/57 (78.9%) in the SG group and 24/46 (52.2%) in the FG group.

In the SG group 2/62 patients encountered moderate neurologic deficits of the right arm (numbness, paresthesia) that were regredient until day of discharge. A potential brachial plexus injury was assumed to be causative. Beside this another 2/62 patients showed, in the beginning of the study, a hyperperfusion syndrome of the right arm (blisters, edema) when being cannulated via graft. The protocol was adjusted with consecutive snaring of the subclavian artery distally to the anastomosis not to exceed a mean arterial pressure of 50 mmHg in the right radial artery.

Hypothermia in the SG leveled at 21.87 ± 3.98 °C. It was significantly moderate than hypothermia in the FG with 17.95 ± 2.02 °C ($P < 0.0001$). Lowest temperature had to be obtained in the SG group whilst 17.66 ± 11.97 min compared with 25.5 ± 15.01 min in the FG group ($P = 0.014$).

Renal failure, as determined by postoperative need for hemofiltration or dialysis, occurred in 7/62 patients (11%) in the SG group versus 14/60 (23%) in the FG group ($P = 0.023$). Visceral malperfusion, as determined by positive CT-scan, angiography or duplex scan, had to be surgically treated in 3/62 versus 6/60 in the SG and FG group, respectively ($P =$ns). However, bleeding was statistically significantly higher in the FG group with 19/60 patients (31%) requiring blood transfusion compared to 10/62 patients (15%) in the SG group ($P < 0.001$).

Table 5
Postoperative laboratory parameters

Parameter	Subclavian group	Femoral group	P-value
CK (peak) (U/l)	1877 ± 2862	2308 ± 5032	0.886
CK MB (U/l)	82 ± 179	71 ± 69	0.2775
Lactic acide (mmol/l)	3.2 ± 2.6	3.6 ± 2.8	0.4307
LDH (U/l)	1187	1246 ±	ns
Creatinine (μmol/l)	136 ± 50	156 ± 80	0.3314
Hemoglobin (mmol/l)	9.4 ± 1.2	12.2 ± 19	0.0073
Platelets (× 109/l)	116 ± 30	123 ± 82	0.4484
ACT (s)	133 ± 43	131 ± 13	0.1174

CK, creatine kinase; LDH, lactate dehydrogenase; ACT, activated clotting time.

Sternal infections occurred in 1/62 (1.6%) in the SG group and 5/60 (8.3%) in the FG group ($P < 0.001$).

Further postoperative results for the two patient groups are listed in Table 5.

4. Discussion

Type A aortic dissection requires instantaneous surgery [7–9]. However, despite recent improvements in diagnostic and surgical techniques, intraoperative mortality remains a still ongoing issue [10]. Perfusion of the true lumen under extracorporeal perfusion in acute Type A dissection is of great concern: malperfusion may contribute to visceral and central nervous system damage, resulting in high morbidity and mortality [3]. Until recently the most accepted method to institute extracorporeal bypass in Type A dissection was to cannulate the femoral artery and to perfuse the brain retrograde via SVC. However, this resulted in a retrograde aortic flow pattern which provoked further dissection or mobilization of calcified aortic debris [11], and the sufficient perfusion of the brain during deep hypothermic circulatory arrest (DHCA) could not be thoroughly assessed. It has been reported that DHCA alone is associated with neurological dysfunction, stroke and mortality when exceeding more than 30 min [12,13]. In conjunction with retrograde cerebral perfusion, overall morbidity and mortality could be reduced, however, outcome was hardly predictable [14] and transient neurologic deficit was reported to be significantly higher in cases with retrograde perfusion [15].

In 1995 Sabik and co-workers described the axillary artery as an alternative site for cannulation in patients with severely atheromatous aorta [16]. Subsequently this technique was further developed and increasingly used in patients with aortic dissection [1–3]. With this procedure an antegrade flow pattern could be achieved, and possible further dissection prevented, since it is uncommon for the right subclavian/axillary artery to be involved with an intimal flap in acute dissection [17]. Cerebral protection was achieved via retrograde perfusion [11] or selective antegrade perfusion via innominate artery and left carotid artery [18].

In June 2000 we have changed our surgical protocol in acute Type A dissections in favor of the antegrade perfusion technique. However, contrary to other authors, we have used the subclavian line to perfuse the body and to selectively perfuse the brain during moderate DHCA. Here, due to lacking data, we estimated the physiologic brain perfusion of 600–800 ml/min with an additionally reasonable safety margin to be adequate. To maintain view during surgical repair, the innominate artery and the left carotid artery were clamped and backflow via left subclavian artery stopped by means of a Fogarty catheter in the distal arch. Perfusion of the subclavian artery proved to be a simple, fast and safe procedure.

Since then we have operated on 62 patients, thus overlooking a reasonable number to compare with our previous technique.

It showed that overall hospital mortality (SG, FG) of 15.6% (19 of 122) was 8.6% (5 of 62) and 23.3% (14 of 60) in the SG and FG group, respectively ($P = 0.0179$). Overall postoperative neurologic impairment, including transient and persistent neurologic deficits, was significantly lower in the SG group ($P = 0.0225$), despite the fact that the brain was only perfused unilaterally via right carotid artery and right vertebral artery. It is a still ongoing debate whether Willis' circle is sufficiently developed in all patients to provide an adequate contralateral perfusion. Anatomical studies have shown a morphologic ideal circle in only 40% [19] of the autopsies with a well-developed anterior communicating artery (ACoA) and posterior communicating artery (PCoA). Mostly the PCoA is abnormal or missing, fewer the ACoA. Rarely both CoA are affected [19]. However, during the unilateral right subclavian perfusion the anterior (via right carotid artery) as well as the posterior half (via right vertebral artery) of Willis' circle are perfused, thus a missing CoA can be compensated and therefore no cerebral ischemia has to be expected. In this context cervical collaterals may support contralateral perfusion [20]. Preoperative screening tests, such as the Transcranial Color-Coded Duplex ultrasonography (TCCD) combined with common carotid artery (CCA) compression tests allow evaluation of the collateral ability of the circle of Willis [21]. Hence, in an emergency situation (Type A dissection) there is hardly time for these investigations.

With regard to these data, time for DHCA may be safely prolonged with the option for even more complex repairs, an issue that has been addressed by other authors [22]. Besides we could show that selective cerebral perfusion lasted 17.66 ± 11.97 min in the SG group compared to 25.5 ± 15.01 min in the FG group ($P = 0.014$). Possibly this is due to the technically more complex retrograde perfusion via SVC with repetitive readjustment of the cannula.

Hypothermia in the SG group leveled at 21.87 ± 3.98 versus 17.95 ± 2.02 °C in the FG group ($P < 0.001$). Our rationale for using moderately deep hypothermia was the unpredictability of the sufficiency of Willis' circle [19], of the extent of supraaortic dissection [17] as well as the grade of visceral malperfusion. With this protocol we had hypothermia as a well-accepted tool for visceral and nervous system protection included. However, it is a well-known phenomenon that DHCA may trigger hematologic and parenchymal consequences. Low temperatures may exacerbate platelet and clotting factor dysfunction. Hypothermia has a deleterious impact on enzymes involved in platelet activation pathways and on enzymatic activity of clotting factors [23]. It could be proved that hypothermia and not heparinization plays the major role in surgical bleeding [24]. In these surveys we believe to find arguments for the interpretation of our findings concerning deep and moderately deep hypothermia: bleeding was significantly higher in the FG group with 19/60 patients (31%) requiring blood products versus 10/62 (15%) in the SG group ($P < 0.01$). Renal failure, defined as need for postoperative hemofiltration or dialysis, occurred in 7 of 62 patients (11%) versus 14 of 60 (23%) in the SG and FG group, respectively ($P = 0.023$). Since profound DHCA has been found as predictor for renal failure, our data support the beneficial effect of a more moderate DHCA for kidney protection [25].

In addition, sternal wound infection rate was significantly lower in the SG group compared to the FG group (1/62 (1.6%) versus 5/60 (8.3%), $P < 0.01$).

In conclusion antegrade cerebral perfusion with mild DHCA provided remarkable brain protection, significantly reduced in-hospital mortality as well as bleeding complications and renal failure. The unilateral subclavian artery approach is a feasible technique in acute Type A dissection.

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Appendix A. Conference discussion

Dr M. Ehrlich (*Vienna, Austria*): In the femoral artery group, you had a mortality rate of three times higher than the subclavian group. Which was 24%. How many patients from this group died as a result of neurological-related complications?

Dr Schurr: There were 2 deaths due to severe neurological problems in the femoral group.

Dr H. Aebert (*Tuebingen, Germany*): I have two questions for you.

The first is, where did you measure the temperatures?

And the second one, did you clamp all the supra-aortic vessels when you did your antegrade cerebral perfusion in all of them?

Dr Schurr: The temperature, was measured in the esophagus and rectally. Concerning your question about the clamping of the supra-aortic vessels, we routinely clamp the innominate artery and the left common carotid artery.

Dr Aebert: Then there is a pretty heavy reflow from the left subclavian artery.

Dr Schurr: Yes, indeed, in those cases where there is troublesome backbleeding we have clamped the subclavian artery. As an alternative we have also inserted a balloon into the descending aorta in order to control heavy backflow.

Dr J. Bachet (*Paris, France*): Was the technique of cannulation chosen casually, or did you decide at a certain time to cannulate all the patients through the axillary artery? In other words, were the different techniques of cannulation randomly chosen in your experience?

Dr Schurr: We started to use subclavian artery cannulation in June 2000, and consecutively, I think, all patients with acute type A dissection were managed by this technique.

Dr Bachet: So there are two different historical series, the first 62 patients had femoral artery cannulation and the last 60 patients had cannulation of the axillary artery?

Dr Schurr: Yes, we analyzed two groups of about 60 patients each.

Dr Turina: May I help explain. Two patient groups are overlapping. Gradual change was introduced first in elective surgery of the aortic arch, where it is easier to perform. We were reluctant to go into acute dissection at the beginning of this study. So there is a considerable overlapping between two series. It is not first one technique and afterwards the other one.

And just one thing, which Dr. Schurr didn't mention because of the shortness of his presentation, is that the Anteflow graft was used in all patients with femoral artery cannulation, so the flow was reinstituted in the antegrade fashion after the distal anastomosis was completed.

Dr J. Bachet (*Paris, France*): Other questions: There was a significant difference in bleeding and infections. How do you explain that? I wonder how the cannulation technique can interfere with bleeding and infection?

Dr Schurr: I think that this finding is not directly related to the cannulation technique but more to the average temperature which we found in the subclavian group. Patients of the subclavian group showed a higher temperature with an average value of 22 °C, this might be an important point in regard to its impact on the coagulation pathway.

Dr Bachet: The same kind of comment applies to the temperature. You said that there was a difference in temperature. But this doesn't depend, I think, on cannulation. It depends on the choice of the surgeon and the perfusionist.

Dr Schurr: Yes, you are probably right. But again, the lower temperature rate might explain the higher bleeding tendency in the femoral group. The more important finding of this study, however, is the improved neurological outcome after subclavian artery cannulation which allows for an antegrade cerebral perfusion.

Dr Bachet: And finally, when you say that with the axillary cannulation you perfused the brain, do you perfuse the brain only with the subclavian cannulation or do you put a cannula into the left carotid artery?

Dr Schurr: We did not insert an additional cannula into the left carotid artery.

Dr Bachet: And you don't think it's very dangerous not to do so?

Dr Schurr: We think that we could manage our patients with type A dissections well by performing subclavian artery cannulation. In addition, continuous neurological monitoring is always performed by bispectral EEG.

Dr Bachet: I personally won't do that.

Dr M. Turina (*Zurich, Switzerland*): In several of these patients, their blood pressure was measured in the innominate artery and in the carotid artery. And the pressure very quickly rises to a level of about 50, 60 mmHg once you cross-clamp the arch vessels. So we found out that at 1 liter flow, or 0.8 liter flow, at 26 degrees, there is just no necessity to do additional measurement. Just flow with this rate and you will not be over perfusing the brain, but you will have an equal pressure in the left and right side of the circulation.