

## COMPLICATIONS IN CARDIAC CATHETERIZATION AND ANGIOCARDIOGRAPHY IN INFANTS AND CHILDREN

### ZAPLETI SRČNE KATETERIZACIJE IN ANGIOKARDIOGRAFIJE PRI NOVOROJENČKIH, DOJENČKIH IN OTROCIH

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**Abstract** – Complications of cardiac catheterization and angiocardiology were reviewed retrospectively in 1074 neonates, infants, and children studied from 1st January 1981 to 31st December 1985. Overall complication rate was 5.2% (56 complications in 54 children). There were 3 cases of death (0.28%) without obvious complication at the time of catheterization. The incidence of major complications was 3.8% and was higher in infants younger than 4 months ( $P < 0.001$ ), and in moderately and critically ill patients than in asymptomatic and mildly ill patients ( $P < 0.001$ ). The highest proportion of major complications occurred in patients with truncus arteriosus communis, double outlet right ventricle, atrioventricular septal defect, univentricular heart, transposition of the great arteries, and tetralogy of Fallot. Arrhythmias were encountered in 66.1% of all major and minor complications. In minor complications the differences in frequency were not found between various age and clinical groups ( $P > 0.05$ ).

The study showed that higher catheterization risk of major complications could be predicted from the age, clinical status, and heart defect of the patient.

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**Introduction** – In 1968 the Cooperative study on complications in cardiac catheterization in infants and children was published (1). Since then technique of cardiac catheterization has improved. Later studies on this problem showed reduction in some of the complications (3).

The purpose of this preliminary report is to present a retrospective review of the complications in infants and children in our institution.

**Materials and methods** – 1074 cardiac catheterizations were performed from 1st January 1981 to 31st December 1985. Newborns were sedated with diazepam during the investigation. A mixture of chlorpromazine, promethazine, and pethidine was used in infants, and ketamine in older children prior to catheterization. Solution of heparin 5 units/ml of 5% glucose in water was used for flushing the catheter. Venous site of entry was used in all catheterizations, and arterial site in 461 investigations.

The classification of severity of illness used by Stanger and associates was modified (3):

A. Asymptomatic patients – without distress, cyanosis, hypoxemia, and congestive heart failure;

B. Mildly ill patients – without distress, nonacidotic, mildly hypoxemic ( $pO_2 > 25$  mm Hg), or in controlled heart failure;

C. Moderately ill patients – hypoxemic ( $pO_2 < 25$  mm Hg), but without acidosis, or in severe congestive heart failure that is only partly controlled with digitalis and diuretics;

D. Critically ill patients – with one or more of the following:

- ventilatory assistance,
- acidemia,
- poor peripheral perfusion and cardiogenic shock.

All the data were collected from hospital catheterization files, where complications during or after catheterization and angiocardiology had been documented. Children were routinely examined immediately, 1 and 4–6 hours, and the next morning after the invasive investigation.

Table 1 shows age distribution and clinical status of infants and children prior to catheteriza-

Age groups	Number of patients in various clinical groups				Totals
	asymptomatic	mildly ill	moderately ill	critically ill	
< 1 week	0	12	13	7	32
1 week – 1 month	1	21	11	3	36
1 month – 2 months	2	8	8	0	15
2 months – 4 months	2	21	10	0	33
4 months – 1 year	60	84	13	0	157
1 year – 4 years	295	110	11	1	417
4 years – 15 years	312	53	4	0	369
>15 years	14	1	0	0	15
Totals	686	307	70	11	1074

Table 1 – Age distribution and clinical status of patients

tion. Major and minor complications were divided in categories used previously in the Co-operative study on cardiac catheterization, in the works of Stanger and associates, and Cohn and associates (1–3). Chi-square test was used to test the differences between various groups.

**Results** – 56 complications occurred in 54 patients. Overall complication rate was 5.2%. Major and minor complications are shown in table 2.

**Major complications** – 53% of all complications.

The incidence of major complications was 3.8% and was significantly higher in infants younger than 4 months than in patients over 4 months of age ( $P < 0.001$ ). The complications were distributed approximately equally in the groups of infants under 4 months of life and drop-

**Major complications and number of cases**

1. Death within 24 h of catheterization without recognized complication – 3
  2. Arrhythmias: any arrhythmia accompanied by hypotension; requiring treatment; or requiring termination of catheterization prematurely – 19
    - a. Cardiac standstill – 3
    - b. Ventricular fibrillation – 0
    - c. Ventricular tachycardia – 1
    - d. Supraventricular tachycardia – 6
    - e. Atrial fibrillation or flutter – 2
    - f. Sinus bradycardia – 3
    - g. 2 AV block – 0
    - h. 3 AV block – 4
  3. Profound hypotension – 0
  4. Arterial problems – 0
  5. Perforation of the heart or vessel – 0
  6. Catheter problems (knotting, breakage etc.) – 0
  7. Serious infections (sepsis, endocarditis, thrombophlebitis) – 0
  8. Serious allergic reactions requiring drugs other than antihistamines – 0
  9. Embolism – 0
  10. Cardiac complications – 1
    - a. Myocardial infarction – 0
    - b. Pulmonary edema – 0
    - c. Hypoxic spells requiring morphine, bicarbonate or oxygen – 1
  11. Serious bleeding – 4
    - a. Requiring surgical intervention – 0
    - b. Requiring transfusion – 4
  12. Pneumothorax – 0
  13. Other – 1
    - a. Combustion – 1
- Total = 29

**Minor complications and number of cases**

1. Arrhythmias: not accompanied by hypotension, not requiring treatment, not requiring premature termination of catheterization – 18
    - a. Supraventricular tachycardia – 3
    - b. Brief ventricular tachycardia with spontaneous resolution while catheter in the ventricle – 1
    - c. Sinus bradycardia – 6
    - d. 2 AV block – 3
    - e. 3 AV block – 5
  2. Arterial problems – 0
  3. Myocardial staining – 0
  4. Catheter problems – 1
    - a. Burst of Rashkind balloon catheter without evidence of embolism – 1
  5. Infections – 2
    - a. Superficial wound infection – 2
  6. Allergic reactions urticaria – 4
    - a. Contrast – 4
  7. Embolism – 0
  8. Bleeding without requiring transfusion – 0
  9. Other – 2
    - a. Spasm of pulmonary vein – 2
- Total = 27

2 AV = second degree atrioventricular block, 3 AV = third degree atrioventricular block

Table 2 – Complications of cardiac catheterization

ped thereafter from about 15 % to about 2 % in the age groups between 4 months and 4 years of age. After 4 years of age no major complication occurred (table 3).

Age group	Number	% of major	% of minor
<1 week	32	15.6	3.1
1 week – 1 month	36	13.9	0
1 month – 2 months	15	20.0	0
2 months – 4 months	33	9.1	9.1
4 months – 1 year	157	2.5	1.9
1 year – 4 years	417	1.9	3.1
4 years – 15 years	369	0	1.9
>15 years	15	0	0

Table 3 – Major and minor complications in various age groups

Major complications were more frequent in moderately and critically ill patients than in asymptomatic or mildly ill patients ( $P < 0.001$ ). The group of moderately and critically ill infants and children represented only 7.5 % of all catheterizations, nevertheless, 46.4 % of all major complications occurred in this group. The highest proportion of major and minor complications were noted in patients with truncus arteriosus communis, double outlet right ventricle, atrioventricular septal defect, univentricular heart, transposition of the great arteries, and tetralogy of Fallot (table 4).

Death within 24 hours after catheterization but without obvious complication at the time of in-

Diagnosis	Number of patients	Percentage of complications
Ventricular septal defect	259	4.2
Tetralogy of Fallot	143	9.1
Atrial septal defect	130	0.8
Coarctation of the aorta	67	4.5
D-transposition of the great arteries	62	9.7
Persistent ductus arteriosus	62	0.0
Pulmonary valvular stenosis	51	1.9
Aortic stenosis	50	2.0
Univentricular heart	38	10.5
Atrioventricular septal defect	36	13.8
L-transposition of the great arteries	22	0.0
Tricuspid atresia	18	0.0
Pulmonary atresia	17	5.8
Double outlet right ventricle	16	18.7
Truncus arteriosus	16	26.7
Normal children	15	0.0
Postoperative catheterization	15	0.0
Miscellaneous	57	0.0

Table 4 – Percentage of complications in various post-catheterization diagnostic categories

vasive investigation occurred in 3 patients which represented 0.28 % of all investigated children. The first patient was a two-day-old critically ill newborn with truncus arteriosus communis type 1. The second patient was a 7-month-old infant with complete form of atrioventricular septal defect and pulmonary arterial hypertension, and the third patient was a two-year-old child with atrial and ventricular septal defect in whom pulmonary arterial hypertension persisted despite previous pulmonary arterial bandage.

Type of the arrhythmia	Number of patients
Supraventricular tachycardia	9
Sinus bradycardia	9
Third degree atrioventricular block	9
Atrial flutter and fibrillation	2
Cardiac standstill	3
Ventricular tachycardia	2
Second degree atrioventricular block	3

Table 5 – Arrhythmias

The most common complications were arrhythmias (table 5). Major and minor arrhythmias represented 66.1 % of all complications. They were more frequent in infants than in children ( $P < 0.001$ ). Cardiac standstill requiring resuscitation occurred in a three-week-old newborn with transposition of the great arteries, in a two-month-old infant with truncus arteriosus communis type 2, and in a two-year-old girl with complete form of atrioventricular septal defect and pulmonary arterial hypertension. All three episodes occurred after completion of catheterization. Resuscitation was successful. Other arrhythmias requiring medication were:

1. Ventricular tachycardia, in a fourteen-month-old child with transposition of the great arteries, was of short duration lasting less than 2 minutes. It was converted to sinus rhythm with lidocaine.

2. Third degree atrioventricular block was terminated after intravenous application of atropin or isoproterenol.

3. Sinus bradycardia resolved also after application of atropin and inspiration of oxygen. This arrhythmia and third degree atrioventricular block were most commonly encountered in patients with tetralogy of Fallot when the operator attempted to enter the pulmonary artery.

4. Supraventricular tachycardia, atrial fibrillation and flutter lasted from 10 to 45 minutes and were converted to sinus rhythm by electrical cardioversion or intravenous injection of digoxin

or catheter – induced ventricular premature contraction.

Bleeding from femoral vein cutdown in 4 newborns required blood transfusion.

Hypoxic spell occurred in an infant with tetralogy of Fallot but resolved with intravenous injection of bicarbonate and morphine.

Hypothermia was noted in the previously mentioned infant with truncus arteriosus communis type 2 after episode of cardiac standstill and resuscitation.

Accidental combustion of the calves occurred in a four-year-old child who lied on a hot pad during the investigation.

**Minor complications** – 48 % of all the complications.

There were no differences in the frequency of minor complications between the infants younger than four months and older children ( $P > 0.05$ ).

The difference in frequency was also not found between various clinical groups ( $P > 0.05$ ).

As in major complications arrhythmias were the most frequently encountered. Short episodes of sinus bradycardia were the commonest.

In a 5-day-old newborn burst of balloon of the atrioseptostomy catheter occurred without evidence of embolism.

Superficial wound infection not requiring surgical drainage occurred in two infants where cutdown of the great saphenous vein was used as the site of catheter entry.

Allergic reaction – urticaria to contrast medium was noticed in four children.

Two episodes of pulmonary vein spasm resolved spontaneously after 20 minutes.

**Comment on major and minor complications**

None of the death could be attributed directly to the catheterization procedure. In the 2-day-old newborn with truncus arteriosus type 2 bradycardia and hypotension developed and the child died 6 hours after investigation. In the child with complete form of atrioventricular septal defect and pulmonary arterial hypertension the cause of death was cardiogenic shock. The death in the third child with atrial and ventricular septal defect and pulmonary arterial hypertension after previous pulmonary arterial bandage was sudden and the reason for it unknown.

The number of arrhythmias was large but all resolved spontaneously or with simple measu-

res. Their absolute number was greater in infants than in children.

Bleeding was a problem in four newborns. Blood loss was noticed around the catheter in the isolated femoral vein. Blood replacement was needed in all of them. These episodes of bleeding might be prevented by securing the proximal end of the vein with untied suture upon which traction should be exerted.

Hypoxic spell did not pose a problem because it responded well to the application of morphine and bicarbonate.

Hypothermia occurred in an infant after prolonged resuscitation. It had to be avoided as it might influence the respiration.

After the accident with combustion the warm pad is not used anymore in older children. In infants the temperature of the water is strictly controlled.

Burst of the balloon catheter filled with contrast medium did not cause embolisation, however, it might be dangerous because part of the rubber material could detach and cause embolization.

Superficial wound infection could be prevented by proper dressing of the wound, and more importantly, by using percutaneous technique rather than cutdown whenever it is feasible.

Allergic reactions occurred after angiocardiology but were not serious. They responded immediately to intravenous medication.

Spasm of the pulmonary vein in 2 cases, when the catheter could not be pulled back to the left atrium, could cause rupture of the pulmonary vein if too much traction would be used.

**Discussion** – The overall incidence of complications was lower in this study than in the Cooperative study and in the study of Stanger and his colleagues (1, 3).

The frequency of death in the present study (0.28 %) was similar to that reported by Stanger and associates (0.26 %) and lower than in the Cooperative study (0.70–0.89 %). It was more frequent in infants than in older children (2, 3). Definite conclusion for the reason for death in my study could not be postulated, however, the young age, poor clinical condition, and the severity of congenital heart defect probably contributed to the fatal outcome.

The incidence of major complications was 3.8 % and was comparable to the study of Stanger and co-workers (2.9 %), Waldman and associates (3 %), and to that in the Cooperative study (3.9 %) (1, 3, 4).

The incidence is clearly lower after the age of 2 months, markedly reduced after 4 months of age, and non-existent after 4 years of age.

The major complications were more frequent in moderately and critically ill patients than in asymptomatic and mildly ill children indicating that severity of illness was a good predictor of the possibility of major complications. The same was not true for minor complications.

The arrhythmias were the most common complications and the findings in this study were in agreement with the data in literature (2, 3). All arrhythmias responded to simple therapeutic measures.

Perforation of cardiac chambers or vessels was not found probably because of the use of the balloon catheters in most newborns and infants.

The sheath was always used in retrograde arterial catheterization. The procedure was not employed in children weighing less than 7 kg.

Additional heparin was not infused after the catheter's entry into the artery. There were no arterial complications.

**Conclusion** – Some of the weaknesses of this preliminary report could be the retrospective nature of the study and limitation of the complications to those recognized clinically within 24 hours. It is likely that a prospective study would be a more exact way of data collection, and extension of observation period to more than 24 hours would probably discover more of the problems. However, the study provides the necessary data, which every catheterization laboratory must collect and assess periodically for modification and improvement of one's own technique and organization of catheterization procedure.

#### Povzetek

V retrospektivni študiji 1074 novorojenčkov, dojenčkov in otrok je avtor pregledal zaplete pri kateterizaciji srca in angiokardiografiji v obdobju od 1. januarja 1981 do 31. decembra 1985. Pogostnost vseh zapletov je bila 5,2% (56 zapletov pri 54 bolnikih). Smrt, brez vidnih zapletov med invazivno preiskavo, je nastopila pri treh (0,28%) bolnikih. Incidenca hujših zapletov je bila 3,8% in je bila večja pri dojenčkih mlajših kot 4 mesece ( $P < 0.001$ ) in večja pri zmerno in kritično prizadetih bolnikih ( $P < 0.001$ ). Največ hujših zapletov je bilo pri bolnikih s skupnim trunkusom arteriozuzom, izstopu obeh velikih žil iz desnega prekata, defektom preddvornoprekatnega pretina, univentrikularnim srцем, transpoziciji velikih žil in tetralogijo Fallot. Aritmije so predstavljale 66,1% vseh hujših in lažjih zapletov.

Pri lažjih zapletih ni bilo razlik v pogostnosti med posameznimi kliničnimi skupinami ( $P > 0,05$ ).

S poznavanjem klinične prizadetosti, srčne anomalije in starosti otrok lahko napovemo tveganje pojavljanja hujših zapletov pri invazivnih srčnih preiskavah pri otrocih.

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