Complications of Left Heart Angiography

A Study of 1,000 Consecutive Cases

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SUMMARY

A study of 1,000 consecutive left heart cineangiocardiograms was made to determine the frequency of various complications. Ten per cent of angiographic procedures caused minor complications such as nausea, vomiting, transient arrhythmias, loss of pulse, or hives. Most of these complications were gone before the patient left the cardiac catheterization laboratory.

Major problems were associated with 3.1% of the angiograms performed. The majority involved either vessel thrombosis (1.2%) or cardiac complications such as arrhythmias, intramyocardial dye injection, or myocardial infarcts (1.4%). Femoral arterial thrombosis was especially frequent in patients with mitral valve disease and low cardiac index. The use of lidocaine-lubricated catheters, tape traction hemostasis, and Fogerty catheter clot removal virtually eliminated brachial arterial thromboses. This route is now used almost exclusively for left heart angiography at our institution.

Most cardiac complications resulted from open-end catheter angiography, especially through transseptal catheters. The frequency of major cardiac complications has decreased markedly since the regular use of closed-tip catheters via the brachial artery route was begun for left heart angiography.

Additional Indexing Words:
Intramyocardial dye Arrhythmias Arterial thrombosis

CINEANGIOGRAPHY of the left side of the heart and the aortic root is a most informative procedure. It is indispensable in quantitating many common lesions such as mitral insufficiency, aortic insufficiency, and left ventricular aneurysm. A recent trend is to carry out more frequent and more detailed angiographic studies during cardiac catheterization.[1]

Several series have reported the frequency of a variety of complications. Lang[2] reported over 11,000 retrograde percutaneous aortograms from which 81 serious complications and seven deaths occurred. In a recent cooperative study of 12,367 cardiac catheterizations by 16 laboratories, the complication rate of angiocardiography was 3.6%.[3] However, in most investigations, it was impossible to discover what type of procedure was likely to be associated with any given adverse effect. For example, intramural dye injections might occur in 2.9% of the cases, but whether they were associated with end-hole or side-hole catheters or were due more frequently to retrograde femoral angiography or transseptal catheter angiography could not be ascertained. The present study was designed to

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Table 1

Patients by Age and Sex

Age (yr)	Males	Females	Total	% of total
Under 1	26	24	50	7.5
1-10	49	45	94	14.1
11-20	57	29	86	12.9
21-30	64	76	140	21.0
31-40	65	85	150	22.4
41-50	42	65	107	16.0
51-60	11	19	30	4.5
61-70	4	7	11	1.6
70 and over	0	0	0	0
Total	318	350	668	100.0

answer these questions and was restricted to left heart and aortic root angiography.

Methods

Cardiac catheterizations that involved cineangiocardiography of the left atrium, left ventricle, or aortic root were studied. For this purpose, the first 1,000 consecutive left heart angiograms performed at Wilford Hall USAF Medical Center between September 1960 and July 1968 were analyzed. For 923 of the 1,000 left heart angiograms, pressure injection was employed and for 77, hand injection. There were 668 patients, 318 males and 350 females. The age distribution is outlined in table 1, and the types of heart disease diagnosed in these patients are listed in table 2. Valvular heart disease accounted for 50.9% and congenital heart disease for 31.1% of the cases.

All patients who had angiography were studied in the Cardiac Catheterization Laboratory. They had left, and usually right, heart cardiac catheterization. Often, other diagnostic procedures were done in addition, such as Fick outputs, indocyanine green-dye studies, or coronary angiograms. However, only the complications resulting directly from left heart angiography were studied. They included problems associated with insertion and placement of the catheter, injection of the dye, and reactions to the dye.

Routine premedication consisted of 100 mg of pentobarbital (Nembutal) given orally on the evening before cardiac catheterization, and 100 mg of pentobarbital given intramuscularly 1 hour before starting the cardiac catheterization. Patients undergoing angiography received exactly the same medications as those undergoing catheterization without angiography. Adverse reactions were treated with appropriate drug therapy as needed. No prophylactic antibiotics were given before or after catheterization. Anticoagulants were discontinued and prothrombin time returned to normal prior to catheterization.

Femoral artery catheterization was done by percutaneous needle puncture with a no. 7 or 8 open-end Teflon angiocatheter passed over a Seldinger wire, which was subsequently removed. Brachial artery catheterization was done by a cutdown over the brachial artery, arteriotomy, and direct insertion of a closed-tip catheter. Although various types of closed-tip catheters were used during the period studied, the no. 7 NIH and the no. 8 Rodriguez-Alvarez catheters were used most frequently. Transseptal catheterization was done by the technic of Brockenbrough and associates.[4]

During the first 3 years of the study, the usual angiogram was made with 40 cc of diprotrizoate sodium (Ditriokon) at 425 pounds per square inch (psi) using a Tavares injector. Subsequent angiograms were done with iothalamate sodium (Angio-Conray) and a Viamonte-Hobbs injector, usually set at 20 ml/sec for 2 sec. Angio-Conray was the contrast agent used in 55.7% of the angiograms in this series, and Ditriokon was used in the remaining 44.3%. Approximately the same number of angiographic procedures were done during each of the years represented in this study.

The charge nurse kept a record of all procedures done during the case, including time of the procedure, any observed complications,

Table 2

Types of Heart Disease

	No. of cases		% of total
Valvular heart disease (total)	340		50.9
Mitral valve		161	
Aortic valve		75	
Mitral and aortic valves		77	
Other combinations		27	
Congenital heart disease (total)	208		31.1
Atrial septal defect		23	
Ventricular septal defect		20	
Patent ductus arteriosus		20	
Coarctation of aorta		18	
Tetralogy of Fallot		9	
Pulmonic stenosis		7	
Transposition of the great vessels		6	
Combination of above and complex cases		105	
Coronary artery disease	24		3.6
Normal	20		3.0
Miscellaneous	76		11.4
Total	668		100.0

Table 3

Pressure Injected Angiograms

Major complications					Route of injection		Total cases	% of total
Local	Cerebral	Cardiac	Misc*	Total				
					Left ventricular		516	51.6
5	1	3	1	10	Via femoral art. catheter	333		
2		1		3	Via brachal art. catheter	98		
		5		5	Via transseptal catheter	28		
	1	1		2	Thru defect (ASD)	57		
					Left atrial		46	4.6
					Via transseptal catheter	42		
					Via defect (ASD)	4		
					Aortic root		361	36.1
3	1	4	1	9	Via femoral art. catheter	296		
2				2	Via brachial art. catheter	65		
			Total	31		Total	923	92.3

*None due to allergy.

electrocardiographic changes, and complaints of the patient. The physician identified all abnormalities observed, and the nurse promptly recorded them on the protocol. The physician also incorporated comments on complications in the progress notes on the chart as soon as the procedure was completed. It is felt that all recognized complications are thus recorded and available for study. The final report of the catheterization also records all known complications. These sources were inspected carefully. To discover any other problems that were not evident at the time of the cardiac catheterization report, all progress notes in each inpatient chart from the time of catheterization to the time of discharge were read. The final narrative summary of the hospitalization also was reviewed. These data were tabulated and all cases in which complications occurred were studied in an effort to find predisposing factors. The route of injection and the chamber receiving the injection for the 923 pressure-injected angiograms are tabulated in table 3. The remaining 77 hand-injected angiograms are similarly detailed in table 4.

Table 4

Hand-Injected Angiograms

		Total cases	% of total
Left ventricular		39	3.9
Via saphenous vein	37		
Via transseptal	1		
Via brachial artery	1		
Left atrial		7	0.7
Via defects	5		
Via transseptal	2		
Aortic root		31	3.1
Via right heart	28		
Via femoral artery	3		
Total			
Hand injected		77	7.7
Pressure injected		923	92.3
Grand total		1,000	100.0

Results

The complications of left heart angiography were tabulated as minor or major. In patients having hand-injected angiograms, no major complications and only one case of vomiting, classed as minor complication, occurred. Thus, except for one case of vomiting, major and minor complications are referable to the remaining 923 pressure-injected angiographic procedures.

Major Complications

Table 5 summarizes the 31 major complications in this study. They are categorized into local, cerebral, cardiac, allergic, and miscellaneous varieties.

Major Local Complications

Major local complications consisted of arterial thrombosis requiring thrombectomy in 12 cases. In eight of these femoral artery thrombosis was present. In all, only 10 patients (including those with minor complications) had loss of femoral pulse. Thus, 80% of femoral artery pulse losses required thrombectomy to save the limb. All thrombectomies

Table 5

Major Complications

			Total cases	% of total
I.	Local (required surgery)		12	1.2
	Femoral artery thrombosis	8		
	Brachial artery thrombosis	4		
II.	Cerebral		3	0.3
	Seizure	1		
	Stroke	2		
III.	Cardiac		14	1.4
	Ventricular fibrillation	7		
	Intramyocardial dye	5		
	Myocardial infarct	2		
IV.	Allergic		0	0
V.	Miscellaneous		2	0.2
	Sickle cell crisis	1		
	Pulmonary edema	1		
		Total	31	3.1

in the present series were successful except for one of the femoral artery, after which rethrombosis occurred and led to loss of the limb.

Of interest is the fact that all eight patients with femoral thrombosis requiring surgery had mitral valve disease and a decreased cardiac index.

Major Cerebral Complications

Three patients had major cerebral complications, including one who had a seizure and two who had strokes. The patient who had a seizure was a 4-year-old who had left ventriculography with 10 cc of Ditriokon at 425 psi. He had no sequelae. One patient, a 51-year-old with mitral and tricuspid disease, developed premature ventricular contractions and then ventricular fibrillation after left ventricular angiography, using 40 cc of Angio-Conray at 425 psi. The patient responded to one shock, but left middle cerebral artery thrombosis occurred, which left him with weakness of the right hand and a minimal aphasia at the time of discharge. The second patient, a 9-year-old girl with aortic insufficiency, became drowsy after two aortograms were made using 10 cc of Angio-Conray at 425 psi. The next day her condition progressed to left hemiparesis. She made an almost complete recovery by the time of hospital discharge.

Major Cardiac Complications

Fourteen patients had major cardiac complications. Ventricular fibrillation occurred seven times. One patient developed left middle cerebral artery thrombosis, described previously. Another patient, a 36-year-old white male with subaortic stenosis, had a left ventriculogram made with 35 cc of Ditriokon at 425 psi through a Brockenbrough transseptal catheter. Intramyocardial injection of dye occurred; the heart could not be defibrillated, and death ensued. His death was the only one in the entire series. In the remaining five patients defibrillation was achieved without problem or sequelae. Five of the patients who had ventricular fibrillation were studied using Angio-Conray. The remaining two were given Ditriokon.

Intramyocardial dye injection was used in two patients while an open-end femoral artery catheter was being used with the usual dosage (40 cc of dye) and pressure (425 psi). Transient ventricular tachycardia occurred, which reverted spontaneously in one patient in whom Angio-Conray was used and after intravenously injected lidocaine in the other who had Ditriokon. He had no sequelae. Another patient, a 4-year-old white girl, was given 15 cc of Ditriokon at 425 psi. She developed ventricular tachycardia after intramyocardial injection of dye with a closed-tip catheter, but no sequelae developed. Two other patients had serious sequelae from the intramyocardial dye. Patient I. S., a 36-year-old Negro female with mitral stenosis and insufficiency, had a left ventricular angiogram done through a Brockenbrough transseptal catheter using 40 cc of Ditriokon at 425 psi. A clinical myocardial infarct developed, but she recovered uneventfully. Patient O. H. had ventricular fibrillation which caused death. Of note is that both of the latter two injections were at the usual pressure and volume but were through open-end transseptal left ventricular catheters.

Myocardial infarcts occurred twice. One infarct was due to intramyocardial dye as

Table 6

Minor Complications

		Total cases	% of total
I. Local		9	0.9
Transient loss of pulse	4		
Local hematomas	5		
II. Cerebral		59	5.9
Headache	20		
Vomiting	38		
Stupor	1		
III. Cardiac (minor or transient arrhythmias)		14	1.4
Ventricular tachycardia	6		
Sinus bradycardia	3		
Sinus arrest	2		
Paroxysmal atrial tachycardia	2		
Bigeminy	1		
IV. Allergic		18	1.8
Sneezing, itching	3		
Minor hives	15		
V. Miscellaneous		0	0
Total		100	10.0

described earlier. The other developed after a routine aortic root angiogram using 40 cc of Angio-Conray at 425 psi through an open-end catheter passed from the femoral artery. No major allergic phenomena occurred.

Major Miscellaneous Complications

One patient, a 22-year-old Negro female with sickle cell disease, had a sickle cell crisis on the day after catheterization. One patient with severe rheumatic valvulitis had pulmonary edema after his second left ventricular angiogram using 35 cc of Ditriokon on each injection. This might have been the result of increased intravascular volume[5, 6] due to hypertonicity of the contrast agents. This could induce pulmonary edema in borderline cases.

Minor Complications

Table 6 summarizes the 100 minor complications found in this study. They are categorized in the same manner as the major complications. Thus, the minor complications may be of local, cerebral, cardiac, allergic, or miscellaneous varieties. All of the minor complications, with the exception of those that were local in nature, were either much alleviated or gone by the time the patient left the laboratory. More than half of the 100 minor complications consisted of transient headache or vomiting (table 6).

Minor Local Complications

Transient loss of pulse occurred twice in the femoral artery and twice in the brachial artery. Five patients developed local hematomas. Three femoral and two brachial studies caused hematomas. Of the three patients with hematomas, one had a previously unknown plasma thromboplastin antecedent (PTA), deficiency, one had a previously unknown plasma thromboplastin component (PTC) deficiency, and one was taking anticoagulants.

Minor Cerebral Complications

Minor cerebral complications included 20 instances of headache, evenly distributed among the various contrast materials. Headache occurred about as often with left ventricular angiograms as with aortic root angiograms. The volume per injection and the pressure had no effect on the incidence. However, 17 of the 20 patients had more than one angiogram.

Vomiting occurred 13 times with Angio-Conray and 25 times with Ditriokon. Inasmuch as these contrast agents were used with about the same frequency, it appeared that Angio-Conray caused vomiting far less often than Ditriokon. Patients who vomited received an average of 1.4 injections, which is about the same as the average number of injections (1.5) of all patients in this series. The site of injection in patients who vomited was left ventricular in 69%, which was higher than the percentage of left ventricular injections in the entire series (55.5%). Vomiting occurred during only one hand-injected angiogram; it was the only adverse effect of the 77 such injections in this series.

Stupor was a transient sequela of an aortic root angiogram, using 40 cc of Angio-Conray at 425 psi in a 24-year-old male, but it cleared in a few hours without neurologic sequelae.

Minor Cardiac Complications

The 14 minor cardiac complications were transient or minor arrhythmias. Ventricular tachycardia occurred six times. It was a sequela of intramyocardial injection of dye three times. It reverted spontaneously on three occasions, but only after intravenous administration of lidocaine on three other occasions. Two of the three patients receiving lidocaine for reversion had Angio-Conray and one was given Ditriokon. No sequelae occurred. Transient sinus bradycardia occurred three times, each in patients given Ditriokon. Sinus arrest occurred twice, both after left ventriculograms using 40 cc Angio-Conray, but it responded promptly to chest pounding. Two patients had paroxysmal atrial tachycardia after left ventriculograms with Ditriokon, and one had bigeminy, but all reverted spontaneously.

Minor Allergic Complications

The only allergic complications in this series were minor. They included two instances of itching of the eyes; one patient developed periorbital and forehead edema, and one patient had sneezing. These three and three of the 15 instances of hives followed the use of Angio-Conray. The other 12 instances of hives followed use of Ditriokon. The hives were primarily small and cholinergic in type. They receded without treatment or after intramuscular administration of diphenhydramine hydrochloride (Benadryl). No serious or prolonged allergic phenomena occurred, and all of these patients were well upon leaving the laboratory. There were no other complications.

Discussion

Minor complications, such as headache, vomiting, and transient small hives occurred in about 10% of angiograms.

Major complications followed 31 of the 1,000 angiograms (3.1%). This finding was similar to that of Hook and Berg[7] who reported major complications in 4% of 521 consecutive catheterizations and selective arteriograms. It was considerably less than the 10% incidence of major complications reported by Sellers and co-workers[8] in a series of 700 left retrograde cineangiocardiograms.

In the present series, table 1 shows that only 7.5% of patients were under 1 year of age.

Table 7

Uncommon Complications of Left Heart Angiography

I.	Local
	Infection[10]
	Perforation[11] or dissection of vessel[7]
	Ulnar ischemic neuropathy[7]
	False aneurysm[7]
	Peripheral A-V fistulae[12]
II.	Cerebral
	Cerebral air embolism[13]
	Atheroma embolus[13]
	Generalized cerebral dysfunction[13]
	Transient blindness[13]
III.	Cardiac
	Perforation of left atrium, ventricle[8] or aorta[9]
	Dislodgment of thrombus[11]
	Coronary artery clot,[11] air, calcium,[14] or tumor embolism
	Bacterial endocarditis[15]
	Perforation of aortic valve cusp[8]
IV.	Allergic
	Acute asthmatic attack[10]
V.	Miscellaneous
	Knotting[16] or breakage of catheter, Seldinger wire[17] or transseptal needle tip[18]
	Electric shock[19, 20]
	Renal shutdown[21]

Kravetz and associates[9] recently emphasized the much higher risk associated with cardiac catheterization in infants and children, whose mortality may be as high as 10 to 15%.

Most of the major complications encountered in the present series (26 of 31) were due either to vessel thrombosis requiring surgery or to cardiac causes. Other major complications have been reported (table 7). No instances of these complications were recorded in this series, and their incidence is presumed to be low.

It is evident then that anything that would tend to reduce the local or cardiac complications of angiography would reduce markedly the incidence of major complications. Our arterial thrombosis rate of 1.2% compared favorably with the 5.7% rate reported by Kottke and associates[22] and was similar to the 1% incidence of pulse loss after brachial artery catheterization reported by Hildner's group.[23]

As noted earlier, study of the eight patients who had femoral artery thrombosis revealed that all had mitral valve disease and a decreased cardiac index. It seems especially important to avoid left heart catheterization by the femoral artery route in patients with mitral disease and a low cardiac index because of their apparent susceptibility to thrombosis.

No such trend was seen in patients who had brachial artery thrombosis. We believe that several changes in technic contributed to the low incidence of brachial thrombosis. They included the routine liberal use of local anesthetic on the arterial catheter, which almost eliminated brachial artery spasm. Another worthwhile change in technic was the substitution of umbilical tape around the distal brachial artery for the metal clamps that were used previously to minimize vessel trauma. Hemostasis was obtained by clamping the tape to the sterile drapes with moderate traction.

A Fogerty catheter was frequently used to remove small clots before closing the arteriotomy. These changes in technic and almost exclusive use of the brachial rather than the femoral artery route made it possible to reduce local arterial thrombosis almost to zero. The other large category of major complications was cardiac. This type did not occur with left atrial angiography. Retrograde left ventricular and aortic root angiograms produced the major cardiac complications. In particular, the use of open-end catheters (retrograde femoral, transseptal, and right heart, placed across septal defects) were the offenders. Experimental studies by Lim and Cadwallader[24] showed that the pressure developed at the end hole of a catheter was always higher than at its side holes. This observation might account for the greater morbidity when using open-end catheters. In the present series, only one cardiac complication occurred when a closed-tip (brachial artery) catheter was used. This was an intramyocardial dye injection which caused transient ventricular tachycardia.

It was especially noteworthy that five complications occurred in 28 left ventricular angiograms done with transseptal catheters. This frequency was more than five times the overall rate and indicated the great risk involved.

We believe that the 3.1% of major complications can be reduced even further by use of newer contrast agents and the modified technics described.

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