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Complications of Pulmonary Angiography

D. T. Anbe, M.D. and E. H. Drake, M.D.*

Although data are available indicating the complication rates for routine cardiac catheterization, information has been lacking on the morbidity of pulmonary angiography in symptomatic patients. This retrospective study was undertaken to assess the "risks" of this procedure, by analyzing all cases undergoing pulmonary angiography from June 10, 1964, to December 31, 1967. Only two deaths were considered to be causally related to the pulmonary angiogram, a mortality rate of 1.4%. The overall complication rate was 15%. There was no correlation of the complications with the average age, or the concentration of the Hypaque used. There was a correlation between complications and the mean pulmonary artery pressure, if the pulmonary angiogram was positive. The patients least likely to tolerate the procedure are the patients in whom a definite diagnosis of pulmonary embolism and knowledge of its extent is imperative. Because of this, and because of the difficulty in establishing causal relationship, the relatively high incidence of complications is not considered to be an indictment of this diagnostic procedure.

Pulmonary embolism is now recognized as a major cause of acute chest disease.¹ Considering the potentially fatal nature of the disorder, the necessity for quickly making an accurate diagnosis is obvious. The clinical diagnosis of pulmonary embolism utilizing the traditional criteria of history, physical findings, electrocardiogram, serum enzymes, routine chest x-rays and radioisotope lung scan has been shown by Hildner and Ormond² to be at times unreliable. Many now feel that the pulmonary angiogram is the most reliable diagnostic test in cases of suspected embolus.³⁻⁷ Although many clinicians have recognized the importance of establishing a definite diagnosis and respect the accuracy of the pulmonary angiogram, they have been reluctant to

subject their patients to the risks of this procedure. This is particularly true when the subject is dyspneic, orthopneic, febrile and hypotensive. Although data are available indicating the complication rates for routine cardiac catheterization, information has been lacking on the morbidity of pulmonary angiography in symptomatic patients. This study was undertaken to assess the "risk" of this procedure.

Materials and Method

The records of all patients subjected to pulmonary angiography at the Henry Ford Hospital from June 10, 1964, to December 31, 1967, were reviewed. These patients were sent for pulmonary angiography because pulmonary embolism was suspected on clinical grounds and/or by chest x-rays and lung scans. Excluded were cases with pulmonary artery contrast injection for

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left atrial visualization as well as pulmonary artery or mediastinal mass delineation.

Each case record and the catheterization note were reviewed. All possible complications were noted in a protocol along with the patient's clinical data. An attempt was made to correlate the complication with the level of the mean pulmonary artery pressure, with age and with the concentration of contrast used, as well as with the presence of pulmonary embolism or other basic underlying disease. We recognized that it is extremely difficult to establish a causal relationship between a diagnostic procedure and death in patients with potentially fatal disease of sufficient severity. Although a very close temporal relationship is desirable, its absence does not mitigate against the probability that the procedure may have contributed to the deterioration of the patient at a later period. All deaths occurring within 24 hours of the procedure were critically analyzed.

Technique of Pulmonary Angiography

The patient is not routinely premedicated. Demerol is given if the patient is in distress with chest pain. Atarax is given to very apprehensive patients. With the patient supine, a cut-down is made in the right antecubital fossa after 2% Xylocaine local anesthesia. A #7 French or #8 French closed-end catheter (Eppendorf or NIH) is then introduced into the vein and guided into the main pulmonary artery under fluoroscopic control with continuous monitoring of the EKG. The pulmonary artery mean pressure is measured with a Statham P23 strain gauge or a water manometer. Thirty-

five to forty ml of Hypaque is then injected under 400-700 p.s.i. with a Cordis pressure injector. Rapid sequence films are obtained with the Schonlander unit. Ninety percent Hypaque is used unless the mean pulmonary artery exceeds 50 mm Hg, then 75% Hypaque is used.*

Results

A total of 143 procedures was performed on 136 patients. One hundred twenty-one angiograms (85%) were uncomplicated. Of these, 57 were positive for embolus (Table I). The average age was 52. The average mean pulmonary pressure was 24 mm Hg. There were 64 negative angiograms in the uncomplicated group. The average mean pressure was 24 mm Hg. The average age was 51 years. Seven of the patients with positive angiograms had follow-up angiograms.

There were 22 procedures (15%) which were complicated. Of these, 8 had positive angiograms. The average mean pressure was 45 mm Hg. The average age was 50. Fourteen had negative angiograms. The average mean pressure was 21 mm Hg. The average age was 57.

The cases with complications were further analyzed according to the type of complications (Table II).

1. *Shock*: Two cases of shock developed post-angiogram. One patient recovered well. In that case, the concentration of Hypaque was unknown. The angiogram was negative. Pulmonary artery

*Ninety percent Hypaque contains 30% sodium diatrizoate and 60% meglumine diatrizoate. Seventy-five percent Hypaque contains 25% sodium diatrizoate and 50% meglumine diatrizoate.

Complications of Pulmonary Angiography

TABLE I

<u>CASES</u>	<u>AVERAGE AGE</u>	<u>MEAN PA PRESSURE</u>	<u>TOTAL PROCEDURE</u>
Positive Angio. Uncomplicated	52 (Range 20-85)	24 mm. Hg. (Range 9-70)	57
Negative Angio. Uncomplicated	51 (Range 22-79)	24 mm. Hg. (Range 7-52)	64
Positive Angio. Complicated	50 (Range 28-82)	45 mm. Hg. (Range 18-90)	8
Negative Angio. Complicated	57 (Range 23-81)	21 mm. Hg. (Range 12-88)	14

pressure: 14 mm Hg. The second case had a 50%-60% occlusion of the pulmonary vascular tree. Pulmonary artery pressure: 30 mm Hg. The patient required Aramine before the angiogram. The blood pressure dropped again after the angiogram. The patient died while being placed on the operating table, with death considered to be due to the underlying disease.

2. *Pulmonary Edema*: One case, 90% Hypaque was used. Pulmonary artery pressure: 16 mm Hg. The angiogram was negative. This patient had chronic congestive heart failure prior to the pulmonary angiogram and continued to have it afterward. The pulmonary edema which developed shortly after the pulmonary angiogram responded well to the usual treatment.

TABLE II

<u>Complication</u>	<u>Average Age</u>	<u>Mean Pressure mm. Hg.</u>	<u>Hypaque 75</u>	<u>Hypaque 90</u>	<u>Hypaque ?</u>	<u>Positive Angio.</u>	<u>Negative Angio.</u>	<u>Total Cases</u>
Shock	52 & 71	14 & 30			2	1	1	2
Pulmonary edema	77	16		1			1	1
Arrhythmia	48 (31-64)	27 (12-55)	2	2	2	3	3	6
Phlebitis	41 & 52	18 & 15			2		2	2
Dyspnea	55	31	1	1	3	1	4	5
Bleeding	51	25			1	1		1
Extra vascular catheter passage	37 & 25							2
Cardiac arrest with survival	53	22			1		1	1
Death	28 & 82	54 & 90		1	1	2		2

3. *Arrhythmia*: Six cases. All responded to treatment. The average pressure was 27 mm Hg. The average age was 48. Two received 90% Hypaque, two received 75% Hypaque, and in two, the Hypaque concentrations were unrecorded. The arrhythmias were:
 - a. Very frequent PVC's—1 case.
 - b. Ventricular tachycardia—1 case.
 - c. Atrial tachycardia changing to atrial fibrillation—1 case.
 - d. Supraventricular tachycardia of unknown type—2 cases.
 - e. Atrial fibrillation—1 case.
4. *Phlebitis*: Two cases. Ages: 41 and 52. Mean pulmonary artery pressures: 18 and 15 mm Hg.
5. *Dyspnea*: (Transient without evidence of pulmonary edema). Five cases. Average age: 55 years. Mean pressure: 31 mm Hg. There was one positive angiogram. One received 90% Hypaque, one received 75% Hypaque. The Hypaque concentration was unrecorded in three cases.
6. *Bleeding*: One patient (who had been given anticoagulants) had some bleeding from the cutdown site. This patient had a positive angiogram.
7. *Catheter Complications*: There were two cases with extravascular passage of the catheter in the extremity. There was one episode of a cracked catheter. There were no instances of cardiac perforation.
8. *Cardiac Arrest With Permanent Resuscitation*: One patient devel-

oped a cardiac arrest while being transferred from the catheter laboratory. The angiogram was negative and the pulmonary artery pressure was 22 mm Hg. The concentration of Hypaque was unknown. The patient was successfully resuscitated but died one week later from pneumonitis and an esophagotracheal fistula.

9. *Deaths Within 24 Hours*: Eleven patients died within 24 hours of the angiogram. This includes the case listed under the complication of shock. Only two of these deaths were considered to be directly attributed to the angiogram and their case histories are presented here. The remaining patients, except for the one who developed shock, were considered to have had uncomplicated angiograms.

Case Reports

S. C. HFH #123 38 84-1

A 28-year-old female was admitted on 5/15/66 for diagnostic evaluation because of chronic congestive heart failure lasting at least eight months. She had had episodes of syncope three weeks and again two weeks prior to admission. These episodes were associated with exertion. She had been taking oral contraceptive pills for approximately 18 months prior to this hospital admission. She had no history of thrombophlebitis, and her last previous hospitalization had been for pneumonia in another hospital. At that time, a heart murmur was found for the first time. At time of her admission to our hospital, her blood pressure was 140/80. There was no cyanosis. She had to remain in the sitting position and became dyspneic when talking. Neck veins were distended at 30° head elevation, with a definite hepatojugular reflux. Moist rales were present in the left base. The heart rate was 80 per minute and regular, S2P was markedly increased, and left parasternal heave was present. S2A and S2M were normal. A Grade II/VI late systolic murmur was present in the 3rd and 4th intercostal space along the left sternal border. This

TABLE III
CARDIAC ARREST OR DEATH WITHIN 24 HOURS OF THE ANGIOGRAM

<u>Patient</u>	<u>Age</u>	<u>Sex</u>	<u>Pulmonary Artery Mean Pressure</u>	<u>Angiogram</u>	<u>Final Diagnoses</u>	<u>Clinical Course</u>
S.C.	28	F	90 mm.Hg.	Positive	Massive embolism: Chronic congestive failure.	Cardiac standstill 10 minutes after angiography. Repeat arrests over 7 hours before death.
Z.M.	82	F	54 mm.Hg.	Positive	Massive embolism: Chronic congestive failure.	Ventricular fibrillation 10 minutes after angiography. Death 1½ hours later.
S.W.	53	M	22 mm.Hg.	Negative	Postoperative pneumonitis secondary to tracheoesophageal fistula.	"Cardiac Arrest" while being transferred from catheter laboratory. Death 1 week later from pneumonitis.
P.H.	71	M	30 mm.Hg.	Positive	Massive embolism: Prostatic carcinoma: Arteriosclerotic heart disease.	Died in operating room while being prepped for an embolectomy.
B.S.	75	M	21 mm.Hg.	Negative	Pulmonary fibrosis: Mitral stenosis: Aortic stenosis.	Respiratory arrest 8 hours after angiography. Subsequent death.
T.C.	57	F	42 mm.Hg.	Positive	Massive embolism: Prostatic phlebitis: Colon and gastric masses.	Died while awaiting embolectomy several hours after angiography.
S.J.	81	F	?	Negative	Congestive failure: Myocardial infarction: Periph. artery occlusion: Emphysema.	Cardiac arrest several hours after angiography: resuscitated and discharged from the hospital.
B.N.	72	F	34 mm.Hg.	Negative	Acute myocardial infarction: Carcinoma of pancreas.	Died several hours after angiography.
E.R.	61	M	?	Positive	Massive embolism: Hydrothorax congestive failure: Pheochromocytoma: Diabetes mellitus.	Comatose and aneuric on admission. Needed Levophed. Died 6 hours after angiography.
H.J.	82	F	42 mm.Hg.	Positive	Massive embolism: Pulmonary fibrosis: gastric ulcer, anemia.	Died several hours after angiography with acute massive hematemesis.
H.W.	63	F	41 mm.Hg.	Negative	Digitalis toxicity: Atrial fibrillation: Congestive failure: Mitral stenosis and regurgitation.	Progressive bradycardia leading to asystole several hours after angiography. Similar cardiac arrest 1 year before.

murmur increased with inspiration. The liver was slightly tender and descended 4 cm below the right costal margin. There was no pedal edema or thrombophlebitis. When a pulmonary angiogram was attempted on 5/18/66, it was found that both the right and left subclavian veins were thrombosed. Subsequently, a right saphenous vein cut-down was made and the catheterization was completed. The patient's pulmonary artery pressure was 120/60 with a mean of 90 mm Hg. She had massive multiple pulmonary emboli. Blood oxygen studies in the right heart ruled out any intracardiac shunts. Approximately 5 to 10 minutes after the contrast injection, the patient developed bradycardia and a cardiac arrest. Resuscitation was successful, but over the next few hours she had multiple cardiac arrests and finally could not be resuscitated. An autopsy was not performed. The clinical diagnoses were multiple pulmonary embolisms, severe pulmonary hypertension and thrombosis of the subclavian veins.

S. M. HFH #054 26 06-5

An 82-year-old female with a history of an old myocardial infarction and chronic congestive heart failure was admitted on 10/29/65 because of increasing dyspnea and abdominal distention. Her blood pressure was 145/90. She was tachypneic and showed neck vein distention at 45° head elevation. Breath sounds were diminished in both lung bases with moist rales in these areas. The heart rate was 72 and regular. There was a Grade III/VI systolic ejection murmur at the left sternal border. The liver was palpated 6 cm below the right costal margin. A 1+ pretibial edema was present. Her condition gradually improved but on 11/19/65 she developed increased dyspnea, right lower chest pain and hemoptysis.

A pulmonary angiogram was performed and was positive for embolus. The pulmonary artery pressure was 76/32, mean 54 mm Hg. Approximately 10 minutes after the contrast injection, the patient developed ventricular tachycardia and then ventricular fibrillation. She was successfully resuscitated. When she awoke, she had a blood pressure of 124/72. Approximately 1½ hours later, she again developed a cardiac arrest but could not be resuscitated. An autopsy revealed an acute septal myocardial infarction, old inferior infarction, multiple pulmonary emboli and a carcinoma of the cecum.

Discussion

In 1950, Dotter and Jackson re-

ported a survey from the United States, Canada, Great Britain and Sweden on death rates following angiocardio-graphy.⁷ A total of 6,824 examinations was recorded with 26 deaths. The most common form of reported death was sudden respiratory arrest following the injection of contrast. Autopsies rarely showed the cause of death. Shehadi, in 1966, quoted the death rate in Lang's series and Fingy's series of angiocardio-graphy as 0.06% and 0.025% respectively.⁸ Braunwald⁹ reported a mortality rate of 0.44% for all forms of cardiac catheterizations in a two-year cooperative study. The overall complication rate was 3.6%. In this same study, there was no difference in the complication rate between cases which had or did not have angiocardio-graphy. There was, however, an overall rate of 1%¹⁰ for complications due directly to the injection of contrast media.

A complication rate of 15% certainly appears high when compared to the complication rate for routine cardiac catheterization with angiocardio-graphy. We have been unable to find any similar report of complication rates for pulmonary angiograms. It would not be valid to compare our results with those of routine cardiac catheterization because the patients who have the signs and symptoms of pulmonary embolism would be expected to be in a more compromised state. The two patients who developed their initial cardiac arrest within minutes of the angiogram were considered to be angiographic mortality. This is a mortality rate of 1.4%. A third patient, who had a cardiac arrest but was resuscitated, died later of post-surgical complications. If this patient is included in the

Complications of Pulmonary Angiography

angiographic mortality group, the cardiac arrest rate would then be 2.1%. Patient S. C. had massive pulmonary embolism with severe pulmonary hypertension. Patient Z. M. had massive pulmonary embolism as well as an acute myocardial infarction. It can be argued that these patients had disease of sufficient severity that death could have been due to the underlying disease rather than the angiogram.

The one case of pulmonary edema developed in a 77-year-old man in severe congestive heart failure. One patient, who developed hypotension, was a 52-year-old male who had a cardiac arrest with resuscitation on the day prior to the pulmonary angiogram. The second patient who developed hypotension required Aramine prior to the angiogram. The Aramine dosage had to be increased after the angiogram. This patient had massive pulmonary embolism. Of the five patients who had increased dyspnea after the contrast injection, three were in prior respiratory distress. One had chronic congestive heart failure, another had wheezing due to bronchial asthma and the third had marked dyspnea and cyanosis. This patient had the only positive angiogram in this classification (Table II). There were no cases of septicemia or wound infection.

All of the arrhythmias precipitated by the angiogram were easily controlled with routine measures. There were no sequellae to the extravascular passage of the catheter, phlebitis of the arm or bleeding at the skin suture line after routine treatment. There were no cardiac perforations.

The incidence of complications was in some degree correlated with the

mean pulmonary artery pressure if the pressure increase was due to pulmonary embolism (Table I). The pressure averaged 45 mm Hg. It must be pointed out that markedly elevated pressures were found in all groups, although more frequently in groups with complications and positive angiograms. The average of the mean pressures from the uncomplicated cases was 24 mm Hg. The average for the two angiographic deaths was 45 mm Hg (Table II). There was no correlation with age or with the concentration of the contrast media used (75% or 90% Hypaque).

Presumably, the use of a different contrast agent could have altered our complication rate. There is ample evidence to show that the sodium salts of contrast agents; e.g., diatrizoate, iothalate and acitrizoate carry a higher toxic potential.¹¹

This review indicates that the patients who need the study most are the patients who, because of their serious clinical condition, are the very ones who will poorly tolerate any procedure. These are the patients who are being considered for a pulmonary embolectomy, a procedure with an operative mortality of 57%.¹³ Subjecting a patient with an acute myocardial infarction to a thoracotomy would certainly carry a mortality rate far higher than 1.4%. It was also significant that there was no mortality in patients with mild symptoms. The mortality rate in those patients would appear to be fairly similar to figures for routine cardiac catheterizations with angiocardiography.

Addendum: Since the completion of this study on December 31, 1967, a total of 147 additional pulmonary an-

giograms has been performed up to August 1, 1969. In this group, only one death occurred as a complication of the angiogram, giving a mortality rate of 0.6%. If the total experience from June 10, 1964, to August 1, 1969, is considered, the mortality rate would be 1.0%.

Summary

A total of 11 deaths or cardiac arrests with resuscitation within 24 hours occurred in 143 pulmonary angiograms performed for suspected pulmonary embolism from June, 1964, to December, 1967. Of these, only two deaths were considered to be causally related to the pulmonary angiogram, giving a mortality rate of 1.4%. The

overall complication rate was 15%. There was no correlation of the complications with the average age of patients, or the concentration of the Hypaque used. There was a correlation between complications and the mean pulmonary artery pressure, if the pulmonary angiogram was positive.

The patients least likely to tolerate the procedure are the patients in whom a definite diagnosis of pulmonary embolism and knowledge of its extent is imperative. Because of this, and because of the difficulty in establishing causal relationship, the relatively high incidence of complications is not considered to be an indictment of this diagnostic procedure.

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