tion in blood pressure from 110/70 torr to 70/40 torr within a minute of administration of a preintubation dose of *d*-tubocurarine. Administration of an additional 100 mg of thiopental and 1 per cent halothane by mask to combat agitation aggravated the cardiovascular collapse, blood pressure dropping from 70/40 torr to unobtainable levels. The patient had no untoward reaction to thiopental, succinylcholine, and pancuronium during her subsequent anesthetic exposures. An attempt was made to document her hypersensitivity by further testing, but the patient was unwilling to cooperate. It should be noted that hypersensitivity to *d*-tubocurarine is difficult to detect by skin tests, since intradermal injections of *d*-tubocurarine produce wheal-and-flare reactions in all subjects tested.[6]

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Right Bundle-branch Block and Complete Heart Block Caused by the Swan-Ganz Catheter

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Pulmonary-artery catheterization for hemodynamic monitoring has found widespread acceptance since the introduction of the balloon-tipped, flow-directed catheter by Swan and Ganz.[1] Transient right bundle-branch block with insertion of the catheter has been reported to occur in patients with acute myocardial infarction.[2] This complication, however, was thought to be extremely rare, since the soft, flexible, balloon-tipped catheters do not carry the same risk of injury to the cardiac conduction system as do conventional cardiac catheters.[3,4] This report documents a high incidence of right bundle-branch block (RBBB) occurring during Swan-Ganz catheterization of the pulmonary artery in patients with stable coronary-artery disease. We also report the occurrence of the potentially fatal complication of complete heart block (CHB) associated with Swan-Ganz catheterization of two patients, with pre-existent left bundle-branch block (LBBB).

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Methods

We recorded serial 12-lead electrocardiograms (ECGs) during the peri-induction period in 46 patients with severe coronary-artery disease (CAD) undergoing anesthesia for elective coronary bypass procedures. Bundle-branch block (BBB) was not present in any patient during the control period. The ECG was recorded prior to and immediately following insertion of the Swan-Ganz catheter via the right internal jugular vein, in awake, premedicated patients. Further ECGs were recorded during induction of anesthesia. ECG leads II and V5 were monitored continuously during anesthesia and operation.

Results

Partial RBBB was apparent immediately following insertion of the Swan-Ganz catheter (fig. 1) in two of

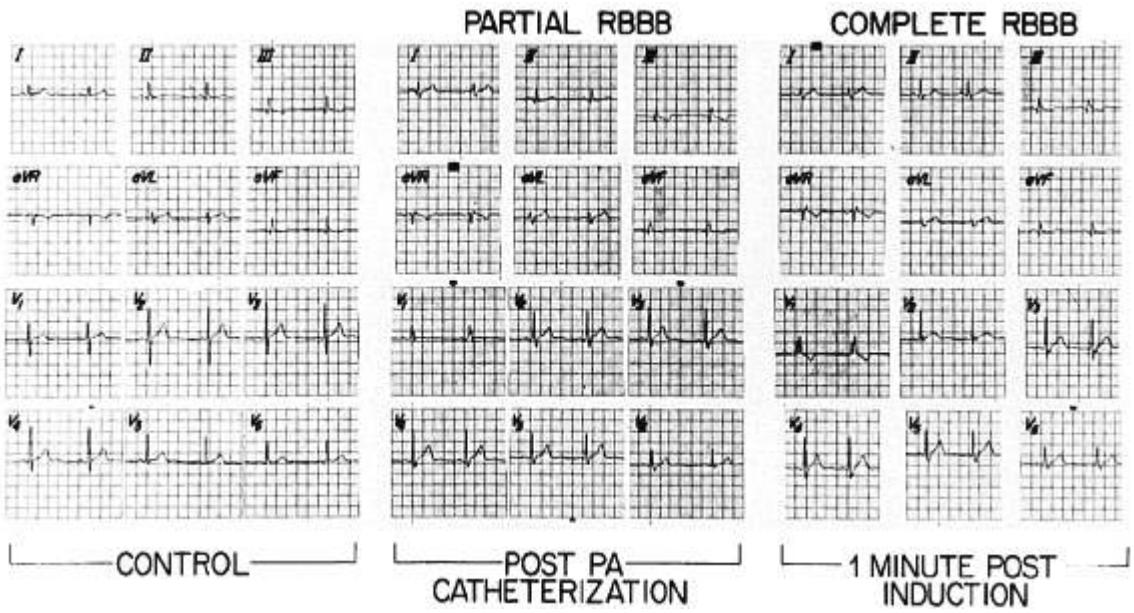

FIG. 1. Twelve-lead ECG of a patient without prior conduction defect, documenting onset of incomplete right bundle-branch block immediately following Swan-Ganz catheterization. This progressed to complete right bundle-branch block a minute after intravenous administration of thiopental, 3 mg/kg.

46 patients. In both patients this progressed to complete RBBB within a minute of induction of anesthesia with thiopental, 3 mg/kg. The abnormality persisted throughout the period prior to institution of cardiopulmonary bypass and was not associated with hemodynamic impairment. In both patients, normal conduction was apparent on the first postoperative day.

Two additional patients, with pre-existing LBBB, experienced complete heart block following insertion of Swan-Ganz catheters via the internal jugular vein, prior to induction of anesthesia for cardiac surgery.

REPORT OF TWO CASES

Patient 1. A 65-year-old man with severe three-vessel coronary-artery disease, and right internal carotid-artery stenosis, was admitted to the Massachusetts General Hospital for elective carotid endarterectomy and coronary-artery bypass grafting. The preoperative ECG revealed LBBB and first-degree atrioventricular (A-V) block. Following premedication with morphine and scopolamine, the patient was transferred to the operating suite, where a Swan-Ganz catheter was inserted via the left internal jugular vein. Shortly after catheterization of the pulmonary artery, complete heart block occurred (fig. 2), associated with severe bradycardia and circulatory compromise. Epinephrine was administered intra-

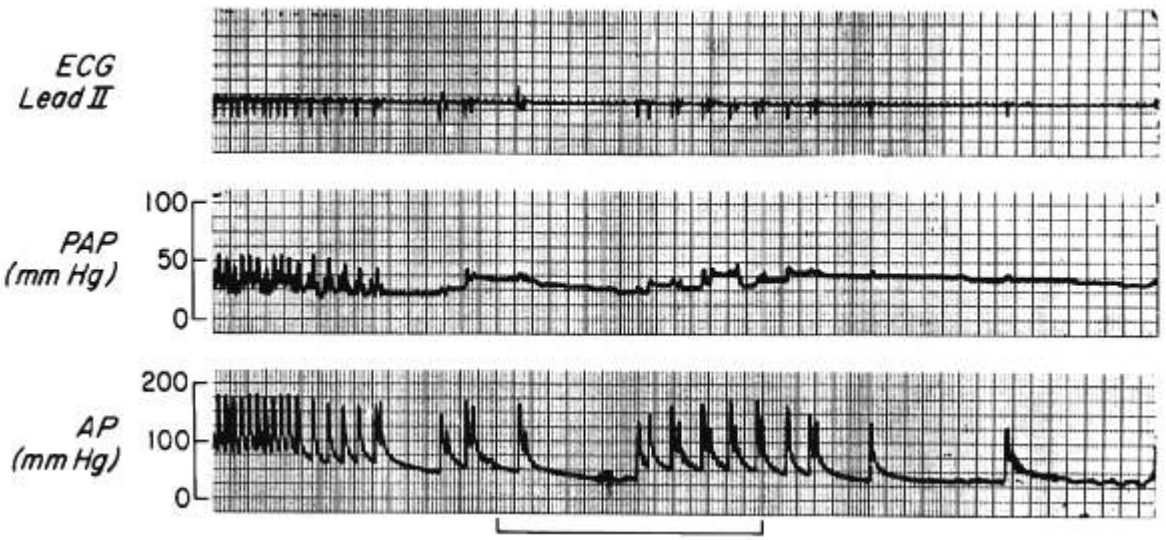

FIG. 2. Heart block occurring shortly after catheterization of the pulmonary artery with a Swan-Ganz catheter in a patient with pre-existing left bundle-branch block. Normal sinus rhythm resumed approximately 12 hours later. The bracket represents 30 sec.

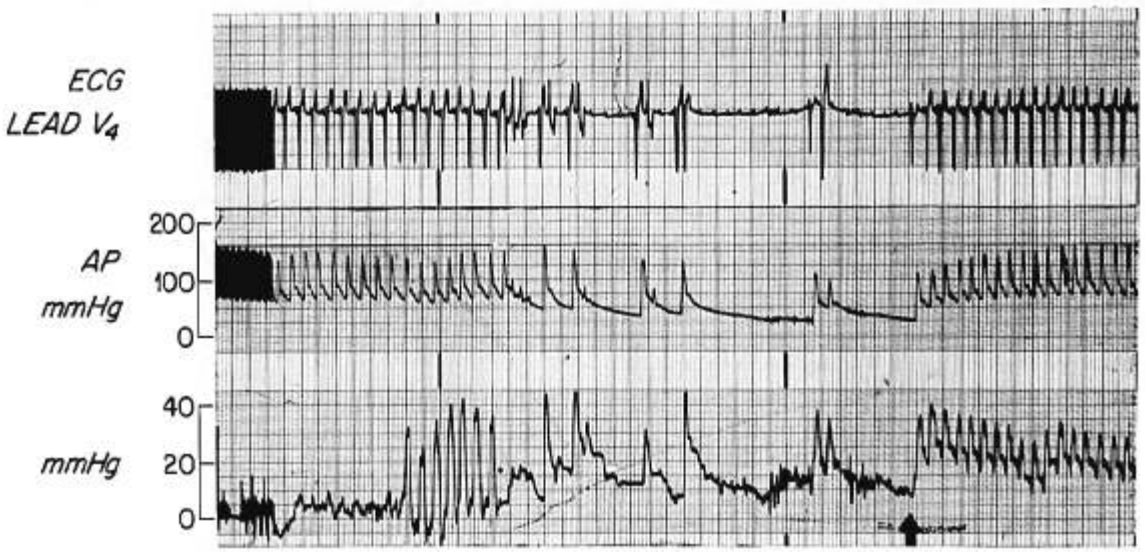

FIG. 3. Transient complete heart block during passage of a Swan-Ganz catheter through the right ventricle in a patient with pre-existing right bundle-branch block. This resolved spontaneously shortly after passage of the catheter into the pulmonary artery. Recorder paper speed: 1 large square per 5 sec.

venously and a temporary transvenous demand pacemaker inserted. Operation was postponed. Normal sinus rhythm resumed the evening of the same day.

Patient 2. A 65-year-old man with severe three-vessel coronary-artery disease was admitted for elective coronary-artery bypass grafting. The preoperative ECG revealed complete LBBB. Following premedication with morphine and scopolamine and transfer to the operating suite, a Swan-Ganz catheter was inserted via the right internal jugular vein. After entrance into the right ventricle, transient complete heart block was observed (fig. 3). This resolved with passage of the catheter into the pulmonary artery. Complete heart block did not recur, and a triple aortocoronary bypass procedure was performed uneventfully. Sequential A-V pacing was instituted prophylactically during separation from cardiopulmonary bypass. A 12-lead ECG on the second postoperative day revealed LBBB. Subsequent ECGs revealed LBBB with first-degree A-V block.

DISCUSSION

Catheter-induced RBBB and complete heart block are well-recognized phenomena among cardiologists performing diagnostic cardiac catheterization, employing a variety of catheters.[5–12] Such conduction disturbances are commonly transient, but chronic interruption of A-V conduction necessitating insertion of a permanent transvenous pacemaker has been reported as a consequence of heart catheterization.[11,12] Wood[5] reported a 5 per cent incidence of RBBB secondary to right-heart catheterization, and speculated that high-grade heart block might result from right-heart catheterization of patients with pre-existing LBBB. Recent data obtained during prospective electrophysiologic investigation of 447 consecutive patients[6] documented a 5 per cent (19/379) incidence of transient RBBB during His-bundle catheterization of the right heart in patients without pre-existent BBB. Furthermore, when pre-existing LBBB was present, a 23 per cent incidence (3/13) of transient complete A-V block was observed.[6] In these cases, interruption of the cardiac conduction system was shown to occur distal to the His bundle, presumably secondary to mechanical trauma to the vulnerable subendocardial portion of the RBB.

The real hazard of development of complete heart block during diagnostic catheterization of the contralateral ventrical in patients with pre-existing unilateral BBB was documented by Stein *et al.* in 1966,[7] in a report of five such cases. Several other cases of the same nature have since been documented.[7,9,10] These observations have led to the recommendation that a temporary transvenous pacemaker should be inserted prior to diagnostic right-heart catheterization of patients with pre-existing LBBB. Both RBBB[2] and complete heart block[14] have previously been reported to occur during insertion of the Swan-Ganz catheter in patients with acute myocardial infarction, whose conduction systems may have been compromised by ischemia.

We have observed the occurrence of RBBB in cardiac surgical patients with coronary-artery disease and the occurrence of transient complete heart block in two patients with pre-existing LBBB as a complication of insertion of the Swan-Ganz catheter. The occurrence of RBBB in two of our 46 patients suggests that the incidence of this complication with use of the Swan-Ganz catheter is similar to the 5 per cent incidence found by others for conventional or His-bundle catheters. Therefore, the soft, flexible nature

of the balloon-tipped catheter does not appear to confer greater safety in terms of the potential for traumatic damage to the subendocardial portion of the RBB. Although the induction of an isolated RBBB is of little significance, we wish to emphasize that when the Swan-Ganz catheter is inserted in patients with preexisting LBBB, the potentially fatal complication of transient complete heart block may ensue in as many as 5 per cent of cases as a result of traumatic interruption of the intact conducting fascicle.[5]

In view of our findings, we suggest that LBBB represents a contraindication to insertion of the Swan-Ganz catheter, unless a method for pacing the ventricle is immediately at hand. This will usually dictate initial passage of a transvenous pacing stylet into the right ventricle prior to the insertion of the Swan-Ganz catheter. Even when the capacity to pace the ventricle is immediately available, the advantages of monitoring pulmonary arterial pressure must be carefully weighed against the possible adverse hemodynamic consequences of loss of normal sinus rhythm, and the attendant atrial contribution to presystolic ventricular filling, before a decision to insert a Swan-Ganz catheter is taken.

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