

changes are numbness and hypesthesia on the lateral surface of the leg and dorsum of the foot.<sup>2</sup> The most common cause of injury to the common peroneal nerve is pressure on the nerve as it crosses the fibula.<sup>1</sup> However, Burkhart and Daly<sup>2</sup> have shown that stretching of the sciatic nerve may also cause damage to the sciatic nerve or to its peroneal branch. These investigators reported that, of five cases of neural injury following surgical procedures done with patients in the lithotomy position, peroneal-nerve injury was demonstrated in three and sciatic-nerve injury in two. In all cases recovery was complete three to eight months after operative procedures lasting as long as 125 min. Other evidence that stretch of the sciatic nerve can lead to footdrop has been documented by Garland and Moorehouse,<sup>3</sup> who reported five cases of transient footdrop and peroneal nerve palsy after nonanesthetized patients had been in the squatting position for periods as long as an hour.

The peroneal division of the sciatic nerve seems to be more susceptible to stretch injury than is the tibial division of the sciatic nerve. This may be related to the lesser amount of supporting connective tissue in the peroneal as compared with the tibial division of the sciatic nerve. Also, since the peroneal division of the sciatic nerve is fixed at two points, the sciatic notch as well as the neck of the fibula, it may be more subject to stretch injury than the tibial division.<sup>4</sup>

By chance, in this particular case pictures were taken of the patient's position. A sketch drawn from these pictures is shown in figure 1. There was no evidence

of external pressure on either leg during the operative period. It is evident, however, that the patient's hips were in extreme flexion, and his position was such that the weight of his torso was concentrated over the gluteal area. We hypothesize that in this very thin individual prolonged pressure on the sciatic nerve, as well as stretch of the nerve from hyperflexion of the hips, produced the nerve palsy. Proper flexion of the hip joints, as well as proper recumbency during the course of the second surgical procedure, avoided exacerbation of the neural injury.

Trauma to the sciatic nerves from pressure and stretch should be added to the list of problems related to operations done with the patient in the sitting position. Avoiding excessive hip flexion, particularly in asthenic individuals, should prevent this complication.

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## Alteration of Pulmonary Blood Flow by Pulmonary-artery Occluded Pressure Measurement

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Swan-Ganz balloon-tipped, flow-directed pulmonary-artery catheters are widely used to measure pulmonary-

artery occluded pressure (PAOP) as an estimate of left atrial pressure (LAP).<sup>1,2</sup> In most instances, occlusion of a small portion of the pulmonary vasculature by the inflated catheter balloon has no effect on cardiac output or systemic and pulmonary venous and arterial pressures. However, when a significant portion of the pulmonary vasculature has been eliminated by disease or surgery, then inflation of a pulmonary-artery catheter balloon might be expected to decrease pulmonary blood flow and hence alter intravascular pressures. The above-mentioned mechanisms appear to account for changes in vascular pressures and cardiac output following inflation of a Swan-Ganz pulmonary-artery catheter balloon in two patients studied after right pneumonectomies.

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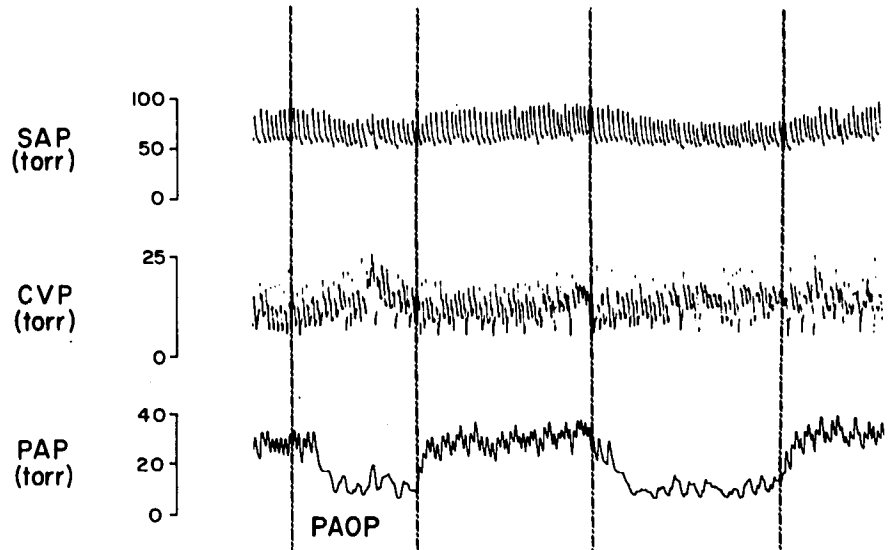
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FIG. 1. Patient 1. Systemic arterial pressure (SAP), central venous pressure (CVP), and pulmonary arterial pressure (PAP). With inflation of the Swan-Ganz catheter balloon to measure pulmonary-artery occluded pressure (PAOP), SAP decreased and CVP increased.

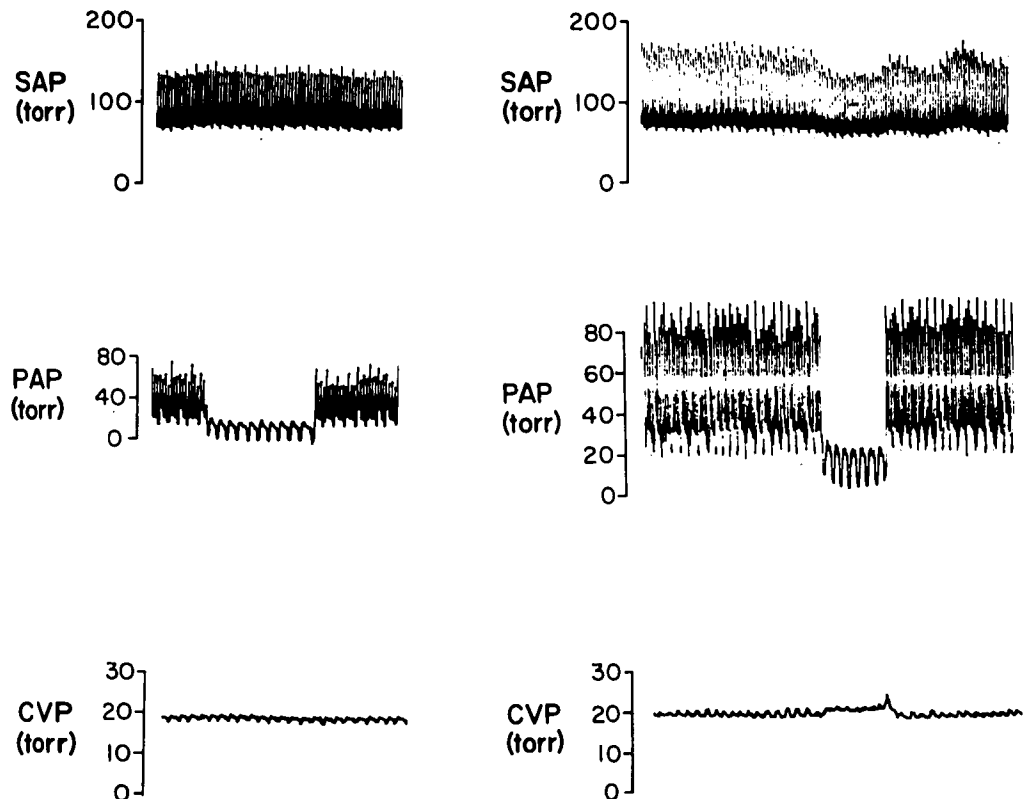


REPORT OF TWO CASES

*Patient 1.* A 64-year-old man had a right pneumonectomy performed for pulmonary carcinoma. On the first postoperative day, during assisted mechanical ventilation, he became hypotensive, and moderate doses of epinephrine were necessary to maintain blood pressure at 100/60 torr. A 5-French double-lumen Swan-Ganz catheter was inserted through the right antecubital vein and positioned by continuous pressure monitoring to obtain PAOP. A roentgenogram of the chest confirmed that the catheter tip was in a central

pulmonary artery. Inflation of the Swan-Ganz catheter balloon to the recommended volume produced a decrease in systemic arterial pressure (SAP), as measured by a radial-artery catheter, and an increase in central venous pressure (CVP), as measured by a catheter in the subclavian vein (fig. 1). Simultaneously, cardiac output, measured by the indocyanine green dye-dilution technique, was reduced from 2.42 to 1.84 l/min, while stroke volume decreased from 18.61 to 12.71 ml. During these measurements there was no change in recorded heart rate or rhythm. On the seventh postoperative day, the patient died of an acute myocardial infarction. Post-

FIG. 2. Patient 2. *Left*, there was no change in systemic arterial pressure (SAP) or central venous pressure (CVP) when pulmonary-artery occluded pressure was measured with the peripherally placed Swan-Ganz catheter balloon, which needed only 0.8 ml air for inflation. *Right*, when the Swan-Ganz catheter was in a more central pulmonary artery, measurement of PAOP resulted in a decrease in SAP and an increase in CVP. (Notice the change in the calibration of PAP.)



mortem examination of the left lung revealed numerous pulmonary emboli, infarction of a segment of the left lower lobe, and centrilobular and bullous emphysema.

*Patient 2.* A 57-year-old man had a right radical pneumonectomy for an adenocarcinoma of the right upper lobe and hilum. The postoperative course was uncomplicated until the fourth postoperative day, when arterial hypoxemia and a supraventricular tachycardia with systemic arterial hypotension developed. Roentgenograms of the chest showed a diffuse infiltrate in the left lung. After endotracheal intubation and digitalization, a 7-French triple-lumen Swan-Ganz catheter was inserted through the right internal jugular vein to assess vascular status. Initially PAOP was obtained with only 0.8 ml air inflating the catheter balloon. When PAOP was measured in this way, there was no change in SAP as measured through a radial-artery catheter or CVP as measured through the proximal port of the Swan-Ganz catheter (fig. 2, *left*). The Swan-Ganz catheter was withdrawn until 1.5 ml air, the recommended balloon volume, was needed to inflate the catheter balloon to obtain PAOP. Now SAP decreased from 160/75 to 130/60 torr, and CVP increased from 18 to 21 torr, as PAOP was measured (fig. 2, *right*). After deflation of the catheter balloon, SAP and CVP immediately returned to their original levels.

#### DISCUSSION

Because of possible complications or inaccurate PAOP measurements when the Swan-Ganz catheter balloon is wedged in a small, peripheral pulmonary artery, it is suggested that the catheter tip be positioned in a more central pulmonary vessel.<sup>3</sup> Pulmonary infarction<sup>3</sup> or pulmonary arterial perforation<sup>4,5</sup> has occurred when the catheter was in a distal pulmonary artery. Shin *et al.* demonstrated eccentric balloon inflation and inability to measure PAOP with peripheral placement of the Swan-Ganz catheter tip.<sup>6</sup>

In the cases presented, inflation of the balloons of centrally positioned Swan-Ganz catheters increased CVP and decreased left ventricular output and systemic arterial pressure. Mechanical obstruction of the pulmonary blood flow provides an adequate explanation for these observations. After pneumonectomy, pulmonary arterial pressure is normal in patients with a normal remaining lung, as right ventricular output is not limited by the residual pulmonary vascular bed.<sup>7</sup> In the two cases presented, postoperative pulmonary hypertension suggested additional destruction of pulmonary vessels, as was confirmed at autopsy in the first case. With inflation of the Swan-Ganz catheter balloon in these patients, there was a further decrease in the pulmonary vascular bed, producing a decrease in pulmonary blood flow, which in turn decreased left atrial filling. This resulted not only in reduction of left ventricular output and systemic arterial pressure, but

also in a decrease in left atrial pressure during PAOP measurement. It appears likely that similar effects will occur with centrally placed catheters whenever a sufficiently large vessel is occluded and/or the pulmonary vasculature is reduced by disease or surgery.

In patients who have normal pulmonary vascular resistance, pulmonary arterial end-diastolic pressure (PADP) equals PAOP and LAP.<sup>2,8</sup> There were 15-torr differences between PADP and PAOP in the two cases presented (fig. 1; fig. 2, *right*). During the measurement of PAOP in these two patients, pulmonary blood flow and left atrial filling were decreased, which produced a decrease in LAP and the large difference between preocclusion PADP and PAOP. An explanation for the lack of agreement between PADP and PAOP in patients with elevated pulmonary vascular resistance is decreased left atrial filling and LAP during pulmonary arterial occlusion by a Swan-Ganz catheter balloon.

These findings demonstrate that pulmonary arterial blood flow can be significantly reduced in certain patients by Swan-Ganz catheter balloon inflation, with resultant decreases in SAP and cardiac output and increase in CVP. As pulmonary blood flow is reduced, left atrial pressure and PAOP as measured are decreased from preocclusion values, and may lead to inappropriate fluid or vasopressor therapy and to errors in values calculated from PAOP.

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