



FIG. 1. The direction of blood flow and point of occlusion of the left innominate vein.

formed, and the left IJV was simultaneously examined as a control. Although a thrombus was not found in the right IJV, we noted that the left IJV flowed cephalad, while the left subclavian vein flowed normally. We immediately removed the pulmonary artery catheter from the right IJV and gently pressed the puncture site, while we confirmed blood flow of the right IJV with duplex ultrasound.

The patient suffered from slight congestive heart failure but did not show any neurologic symptoms after surgery. He was discharged from hospital three months after surgery. Blood flow reversal of the left IJV and normal blood flow of the right IJV was again confirmed using duplex ultrasound.

Rupture and subsequent ligation of the left innominate vein is a rare but possible complication during open heart surgery. In this case, it was believed that the blood flow of the left subclavian vein was re-

versed toward the transverse sinus in the cranium through the left IJV, adding to the blood flow at the confluent sinus and draining through the right IJV (fig. 1). In other words, the blood in the right IJV came from the entire brain and left upper extremity. Because it has been reported that occlusion of both internal jugular veins caused cerebral dysfunction,<sup>2,3</sup> when the left innominate vein was ligated during open heart surgery, the catheter in the right IJV was promptly removed to avoid complications that might occur if thrombus developed in the lumen of the right IJV.

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#### REFERENCES

1. Yonei A, Nonoue T, Sari A: Real-time ultrasonic guidance for percutaneous puncture of the internal jugular vein. *ANESTHESIOLOGY* 64:830-831, 1986
2. de Bruijn NP, Stadt HH: Bilateral thrombosis of internal jugular veins after multiple percutaneous cannulations. *Anesth Analg* 60:448-449, 1981
3. Stewart DR, Johnson DG, Myers GG: Hydrocephalus as a complication of jugular catheterization during total parenteral nutrition. *J Pediatr Surg* 10:771-777, 1975

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## Protamine: A Cardiotoxic Agent with Negative Inotropism

*To the Editor:*—Morel *et al.* provided an excellent study on adverse cardiopulmonary effects of protamine.<sup>1</sup> We agree that the degree of the response to protamine correlated with the rate of protamine administration. However, we do not understand why the authors concluded that it was the rate of generation of heparin-protamine complexes, rather than the excessive amount of circulating free protamine, that initiated the sequence of adverse responses. We think that either one is possible when protamine is infused rapidly.

In a recent paper we described the direct effects of protamine on myocardial contractility in isolated rabbit heart.<sup>2</sup> The results showed that protamine infusions exerted significant dose-related progressive negative inotropic effects at concentrations of 0.01, 0.1, and 0.25 mg/ml. At 0.5 mg/ml, it caused an almost complete loss of contractility, with peak developed tension of only 6% of control value or total arrest despite continuous electrical stimulation. A similar pattern of changes was noted in dT/dt. The severely depressed myocardial septa following the large dose of protamine (0.5 mg/ml) developed intermittent electromechanical uncoupling. They either failed to recover any contraction at all (two cases) or took  $35 \pm 4$  min to recover to the initial level.

The pathophysiologic mechanism to develop the adverse effects of protamine infusion remains controversial\* and may be multifactorial. Our study suggested that the cardiotoxic depressant effect of protamine

in large doses may play a role, particularly in rapid infusion. More studies need to be done. We also found that heparin was a myocardial depressant but was not cardiotoxic,<sup>3</sup> and that heparin-protamine complexes caused less myocardial depression than did protamine itself.†

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#### REFERENCES

1. Morel DR, Costabella PM, Pittet J-F: Adverse cardiopulmonary effects and increased plasma thromboxane concentrations following the neutralization of heparin with protamine in awake sheep are infusion rate-dependent. *ANESTHESIOLOGY* 73:415-424, 1990
2. Lee TS, Virtusio L, Lin YL, Chen BJ: Cardiotoxic effect of protamine on isolated rabbit myocardium (abstract). *Crit Care Med* 18:S176, 1990
3. Lee TS, Virtusio L, Lin YL, Wu Y: Heparin: A myocardial depressant? (abstract). *ANESTHESIOLOGY* 73:A605, 1990

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\* Unpublished data.

† Lowenstein E: Lessons from studying an infrequent event: Adverse hemodynamic response associated with protamine reversal of heparin anticoagulation. *J. Cardiothorac Anesth* 3:99-107, 1989.