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Increasing the Functional Gauge of the Side Port of Large Catheter Sheath Introducers

HENRIK W. ANDERSEN, M.D.,* JONATHAN L. BENUMOF, M.D.,† FRANK R. TROUSDALE,‡ GEORGE T. OZAKI§

In an *in vitro* crystalloid fluid infusion system, the functional gauge (infusion pressure–flow relationship) of the side port of a Cordis large catheter sheath introducer (Cordis Corporation, Miami, Florida) is much less (20-gauge) than the theoretical gauge predicted by the known diameters of the side port tubing and the catheter sheath (both 12-gauge).[1] The insertion of a no. 7-French pulmonary artery catheter within the sheath introducer caused only a very slight further reduction in the functional gauge of the side port channel. The major factor that appeared to limit the flow rate of fluid in the side port channel was the very small size of the side port hub as it is currently molded into the female head of the catheter sheath. It was hypothesized that if the side port hub were enlarged, irrespective of the presence of a pulmonary artery catheter within the sheath introducer, the utility of the side port as an independent large bore intravenous line would proportionately increase. Because situations may arise where the sheath introducer provides the only intravenous access route and because it is important to understand how well a given fluid infusion route functions, we thought it important to test this hypothesis.

METHODS

Four mongrel dogs were anesthetized with 25 mg/kg pentobarbital, intubated, and mechanically ventilated. Systemic arterial and central venous pressures were monitored via catheters placed in the left femoral artery and vein. The right internal jugular vein was exposed by cut down for placement of the various test catheters. The fluid infusion system for the various internal jugular vein catheters consisted of a Travenol Viaflex® 1000-ml administration bag, a McGaw Metriset® (100-ml volume chamber) and Travenol 2.4 M Solution Administration Set®. The fluid infusion system was pressurized by adding air above the fluid column in the Metriset and the pressure in the Metriset air chamber was directly measured by a mercury manometer (Baumanometer®, W. H. Baum Company, Inc., Copiaque, New York). Fluid for the infusion system was either 0.9 per cent sodium chloride or heparinized autologous whole blood (hematocrit range 38–44 per cent) and fluids were infused and blood removed so that the central venous pressure was always 4 to 8 mmHg.

We modified a Cordis large catheter sheath introducer by removing the manufacturer's side port hub, enlarging the remaining orifice (into the female head of the sheath

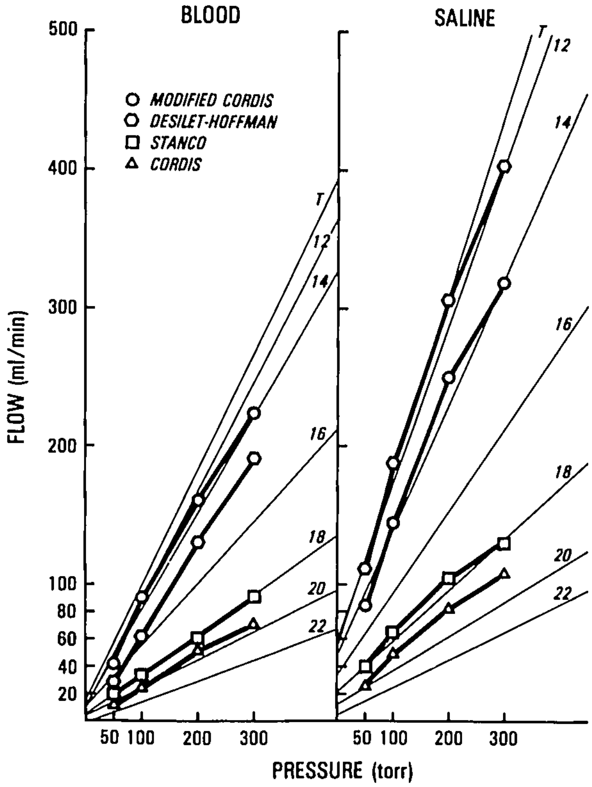

FIG. 1. The infusion pressure–flow relationship for various sized peripheral intravenous catheters (range 22–12 gauge + T = intravenous tubing) and various large catheter sheath introducers (listed as a separate legend within the figure). The data for the peripheral intravenous catheters are plotted as linear regression lines ($r \geq 0.998$) and the gauge for each regression line is indicated on the right hand side of each panel. Left panel = blood data; right panel = saline data. Infusion pressures were measured at 50, 100, 200, and 300 torr. All standard errors for the mean data for the sheath introducers were ≤ 10 per cent of the mean and therefore are not shown.

* Fellow in Anesthesia.
† Associate Professor of Anesthesia.
‡ Staff Research Associate.
§ Developmental Engineer.

Received from the Department of Anesthesia, University of California at San Diego, Anesthesia Research Laboratory, La Jolla, California 92093. Accepted for publication July 13, 1981. Supported by UCSD Anesthesia Department.

Address reprint requests to Dr. Jonathan L. Benumof: Anesthesia Research Laboratory, T-001, La Jolla, California 92093.

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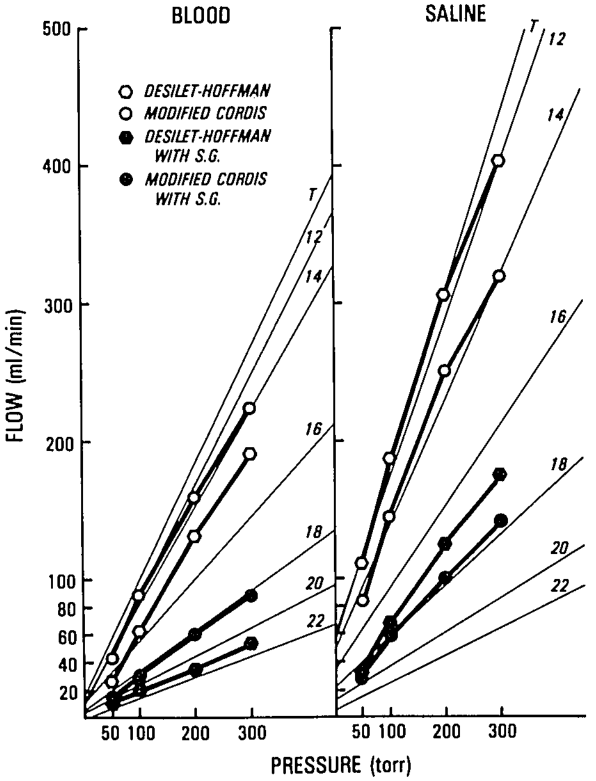

FIG. 2. The figure format is similar to fig. 1. The important comparison is between sheath introducers with large side port hubs (modified Cordis and Desilet-Hoffman) which do not (open symbols) and do (closed symbols) have an indwelling Swan-Ganz catheter. The insertion of the Swan-Ganz catheter into the lumen of these sheath introducers dramatically reduced the pressure-flow relationship. S.G. = Swan-Ganz catheter.

introducer) and then molding a 14-gauge female adaptor to the enlarged orifice. In addition to the Cordis and modified Cordis, we studied two other catheters: the Stanco® (Stanco Medical, Inc., Goleta, California) and the Desilet-Hoffman® (Cook Incorporated, Bloomington, Indiana) sheath introducers. The Cordis and Stanco side port hubs were obviously relatively small and the Desilet-Hoffman and modified Cordis side port hubs were obviously relatively large.

In each dog, every internal jugular vein catheter was tested in random sequence with both blood and crystalloid. Both of these fluids were infused twice for 30 s at 50 and 100 mmHg and for 15 s at 200 and 300 mmHg and the average of these two determinations was used as the flow rate for a given catheter, type of fluid, and infusion pressure in a given dog. In each dog we measured the infusion pressure-flow relationship of 22-, 20-, 18-, 16-, 14-, and 12-gauge peripheral intravenous catheters (Abbocath-T® no. 4535 series) and the pressure-flow relationship of the side and entry ports of the unmodified Cordis, Stanco, and Desilet-Hoffman, and the modified Cordis large catheter sheath introducers. Each of these four large catheter sheath introducers were tested in the following experimental sequence: 1) infusion through the introducer side port; 2) infusion through the introducer side port with no. 7 French Swan-Ganz catheter in place; 3) infusion through a 14-gauge peripheral intravenous catheter placed through the large catheter entry port; and 4) simultaneous infusion through the sheath introducer catheter side port and the 14-gauge peripheral intravenous catheter in the large catheter entry port.

RESULTS

The infusion pressure-flow relationship for the 22-12-gauge peripheral intravenous catheters are shown in figs. 1, 2, and 3 (left panel for blood, right panel for saline) as reference background regression lines (r ≥ 0.998 for all catheters). Figure 1 shows that the sheath introducers with the large side port hubs (modified Cordis and Desilet-Hoffman) permitted the largest flow (comparable to a 12-15-gauge peripheral intravenous catheter) and the sheath introducers with the small side port hubs (Cordis and Stanco) permitted a much lower flow (comparable to a 18-20 gauge peripheral intravenous catheter). Figures 2 and 3 show the pressure-flow relationship through the side port of each of the four introducers when a Swan-Ganz catheter is in place. The

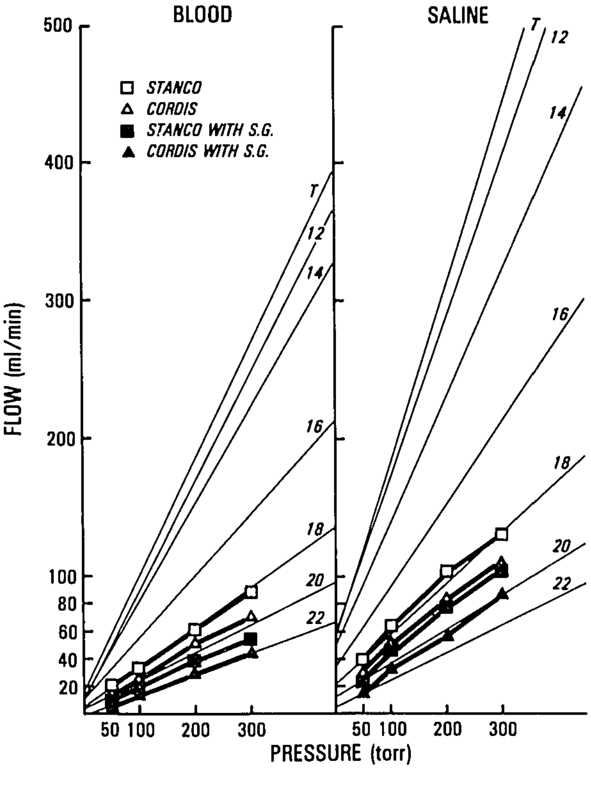

FIG. 3. The figure format is similar to fig. 2 but the sheath introducers studied have small side port hubs (unmodified Cordis and Stanco). The insertion of the Swan-Ganz catheter within the lumen of these sheath introducers had only a little effect on the side port channel pressure-flow relationship. S.G. = Swan-Ganz catheter.

presence of a Swan–Ganz catheter in the lumen of the sheath introducers with large side port hubs dramatically decreased (approximately 70 per cent) the side port flow (fig. 2) whereas the presence of a Swan–Ganz catheter in the lumen of the sheath introducers with small side port hubs only moderately decreased (approximately 30 per cent) the side port flow (fig. 3). Infusion of fluid through a 14-gauge peripheral intravenous catheter placed in the large catheter entry port caused the sheath introducer to have a 14-gauge pressure–flow force relationship. Simultaneous infusion of fluid through both the side port and a 14-gauge peripheral catheter in the large catheter entry port caused a slightly greater than 12-gauge pressure–flow relationship.

Discussion

A major indication for Swan–Ganz catheter monitoring is accurate assessment of intravascular volume and the catheter is therefore used to help manage patients who may lose a large amount of blood rapidly. Large catheter sheath introducers greatly facilitate the correct placement of the Swan–Ganz catheters and if the large catheter sheath introducer contains a side port, the introducer may then function additionally as an intravenous access route for fluid and drug administration. In situations where the sheath introducer provides the only intravenous access route, it is obviously important to understand exactly how well a given sheath introducer functions.

We found that when the lumen of the sheath introducer did not contain an indwelling pulmonary artery catheter decreasing the size of the side port hub from large to small greatly decreased side port channel flow (as Poiseiulles' law would predict). When the size of the side port hub was large, placement of a pulmonary artery catheter within the lumen of the sheath introducer also greatly decreased side port channel flow. Therefore, the presence of a Swan–Ganz catheter within the lumen of the sheath introducer also is a major determinant of side port channel resistance. When the side port hub was small, placement of the Swan–Ganz catheter within the lumen of the sheath introducer had a much smaller effect on side port channel flow rate. Therefore, the presence of a Swan–Ganz catheter within the lumen of the sheath introducer is a nearly equal resistance to side port channel flow as a small side port hub. Finally, we found that the functional gauge of the sheath introducer is converted to a 14-gauge peripheral intravenous catheter when this peripheral catheter is placed through the large catheter entry port.

Based on these findings, several clinical management decision-making pathways are obvious. When a Cordis or Stanco sheath introducer is *in situ*, and a Swan–Ganz catheter is in place, then the side port channel will function only as a very small bore intravenous route. Even when the Swan–Ganz catheter is removed, the side port channel will function only as a small bore intravenous route. When a sheath introducer with a large side port hub is *in situ* and a Swan–Ganz catheter is in place within the lumen of the sheath introducer, then the side port channel will only function as a small bore intravenous route. However, under these circumstances removal of the Swan–Ganz catheter will increase the side port channel from a small bore to a large bore route. Finally, infusing fluid through both the side port of the sheath introducer and a 14-gauge catheter placed through the large catheter entry port of the sheath introducer will produce the greatest flow rates and in an extreme emergency would be the maneuver of choice for rapid volume administration. All of these therapeutic options require removal of the pulmonary artery catheter (a major infusion fluid guideline and endpoint) and they thereby emphasize the desirability of obtaining an anatomically separate large bore fluid infusion site.

Based on our findings, a sheath introducer which has a large side port hub appears to be more desirable than one with a small side port hub. Since the side port of any currently manufactured sheath introducer functions as a small gauge intravenous route when a pulmonary artery catheter is in place, the ideal large catheter sheath introducer may be one that has a large side port hub *and* an enlarged sheath lumen. Under these circumstances the side port would function as a large bore intravenous route while the pulmonary artery catheter remained *in situ* and continued to function as the fluid influsion rate guideline/endpoint.

References

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