
THE CLINICAL IMPORTANCE OF UNRESTRICTED FLOW IN HOSPITAL SUCTION SYSTEMS

Michael J. Neary, MD
John J. Hill, BA, RRT-NPS
Bonita Weyrauch, RN, CWS, DNC, CCT
Kevin Klocek, EMT, BSBME, MBA
Randolph Cremer, CBET

Background

Suction is used clinically for a wide variety of interventions such as airway clearance, surgical field visualization, gastric drainage and thoracic decompression.

In the acute care setting, suction is most often generated centrally by a large stationary pump and distributed to clinical areas via fixed pipelines. The high vacuum available in the piping system must be regulated down to clinically safe and effective levels prior to application to patients.

Suction regulators are commercial devices used to safely reduce the high vacuum pressure available from the central supply prior to therapeutic delivery. These devices, when properly installed and maintained, effectively isolate the patient from high levels of suction, thus mitigating potential harm and ensuring patient safety.

Two principal metrics define the clinical application of suction to patients: pressure and flow.

Pressure defines the amount of force per unit area that is delivered to a collection apparatus and patient. This pressure is familiar to caregivers as the reading displayed on the gauge of the suction regulator. When a catheter tip or clinical suction attachment becomes adhered to intact tissue, it is this level of pressure that determines the localized force applied to the intact tissue. High levels of pressure can cause localized barotrauma as evidenced by capillary rupture, localized tissue necrosis, or clinically significant hemorrhage.

Flow is a measure of the volume the system is able to withdraw per unit time. Flow is essential to facilitate the fastest movement of materials through a suction line. The rate of flow is not displayed to the clinician but is evidenced by the movement of fluid and debris away from an anatomical site. A high flow rate is essential to

ensure the rapid removal of fluid from a site in emergent cases such as airway clearance and surgical field visualization.

In accordance with industry standard codes, hospitals are required to ensure high flow is available to the caregiver from the wall outlet. Too many attachments to this wall outlet, such as extra suction regulators, can negatively affect the amount of flow that can be delivered to the suction tip reducing the clinical efficacy to the patient.

Clinical Significance

Safe suctioning is achieved by facilitating a high rate of flow at the lowest operating pressure. When the flow in a suction circuit is restricted, higher pressures will be required to move secretions. High suction pressures can cause immediate and long-term adverse physiological effects. Clinicians are not able to adjust the level of flow during a procedure, as this is dependent on the choice of equipment used. The greatest numbers of blind suction procedures are performed in the range of 60-150 mmHg. Clinicians are discouraged from using suction in excess of 150mmHg for routine removal of secretions from endotracheal tubes.

Every component in the suction system, from the regulator to the patient attachment, will impart a restriction on the available flow. Once a system has been setup, the only option available for caregivers to increase flow of the suction system is to increase the level of suction. Clinicians may attempt to turn the suction to a higher vacuum level in order to encourage higher flow through a restricted system.

The level of suction pressure in the system is typically relayed to the caregiver via a gauge on the suction regulator. In a static (occluded) circuit that has been allowed to equilibrate, the pressure displayed on this gauge will be the same pressure throughout the entire system. Clinically, most circuits are not static. In a flowing system

with restrictions in the collection circuit, the gauge reading can be much lower than the regulated setting of the regulator.

When higher levels of suction are applied to the system, flow will necessarily be higher. However, once the system becomes attached to intact tissue, a potentially higher level of suction than desired will be applied to tissue. This is typically why the standard of care is to set the regulator while occluding the catheter to ensure the maximum pressure applied to patient tissues will not exceed a specified value.

Adverse events have been reported to the FDA resulting from the over application of suction pressures to delicate tissues. Adverse events have also been reported from the inability to remove fluid in a timely manner from a patient with a compromised airway.

Purpose

To determine the absolute flow capability of commercially available suction equipment when connected to a code compliant outlet across clinically appropriate suction levels.

Methods

A code compliant hospital suction outlet was used for all testing. A Boehringer Laboratories, Inc. Model 7990 calibrated Suction Outlet tester was used to verify code compliance of the single outlet used for all evaluations.

National Fire Protection Agency (NFPA) code requires the wall suction outlets to provide a minimum flow of 3 SCFM (Standard Cubic Feet Per Minute, approximately 85 liters per minute). The NFPA code flow is shown as a dashed horizontal line on Figure 3.

Eighteen (18) inches of 5/16" internal diameter reinforced tubing was used to connect a calibrated 0-200SCFH (standard cubic feet per hour) flow meter to the regulator under test.

There are two commonly used suction regulators found in the hospital environment. One is a general-purpose regulator which offers the clinician regulated suction from 0-200mmHg and an override to apply full line suction, these are commonly known as continuous regulators. The other common regulator is one that automatically turns on and off suction for use with gastric decompression or feeding, these are commonly known as intermittent regulators.

A variety of commercially available continuous regulators were chosen from five different manufacturers. Each regulator to be tested was connected to the standard wall outlet via the same D.I.S.S. (Diameter Index Safety System) coupling. Manufacturer provided inlet fittings were used.

Regulators were connected to the flow meter and then adjusted in an occluded circuit to one of three clinically appropriate operating pressures: 50mmHg, 100mmHg, and 200mmHg.

Once the desired dead-ended condition had been achieved the circuit was opened to the atmosphere and the flow was read from the flow meter. Three replicates at each flow setting were read for each piece of equipment and the average of these readings was reported. The data from these flow tests is reported in Figure 1. Graphical representation of these data is shown in Figure 3.

The Boehringer continuous regulator provided an average flow of 66lpm at a setting of 50mmHg. The next test was to see what suction setting would be required on competitive units to achieve similar performance. Each competitive regulator was connected to the NFPA code compliant outlet and to the calibrated flow meter as described above. The unit was turned to its 'ON' position and the suction adjustment knob of the unit was turned up until 66lpm of flow could be obtained. The circuit was then occluded and the vacuum setting from the circuit was read on the regulator gauge. These readings were repeated three times on each unit to report an average value. These values are shown below (see Figure 2).

Results

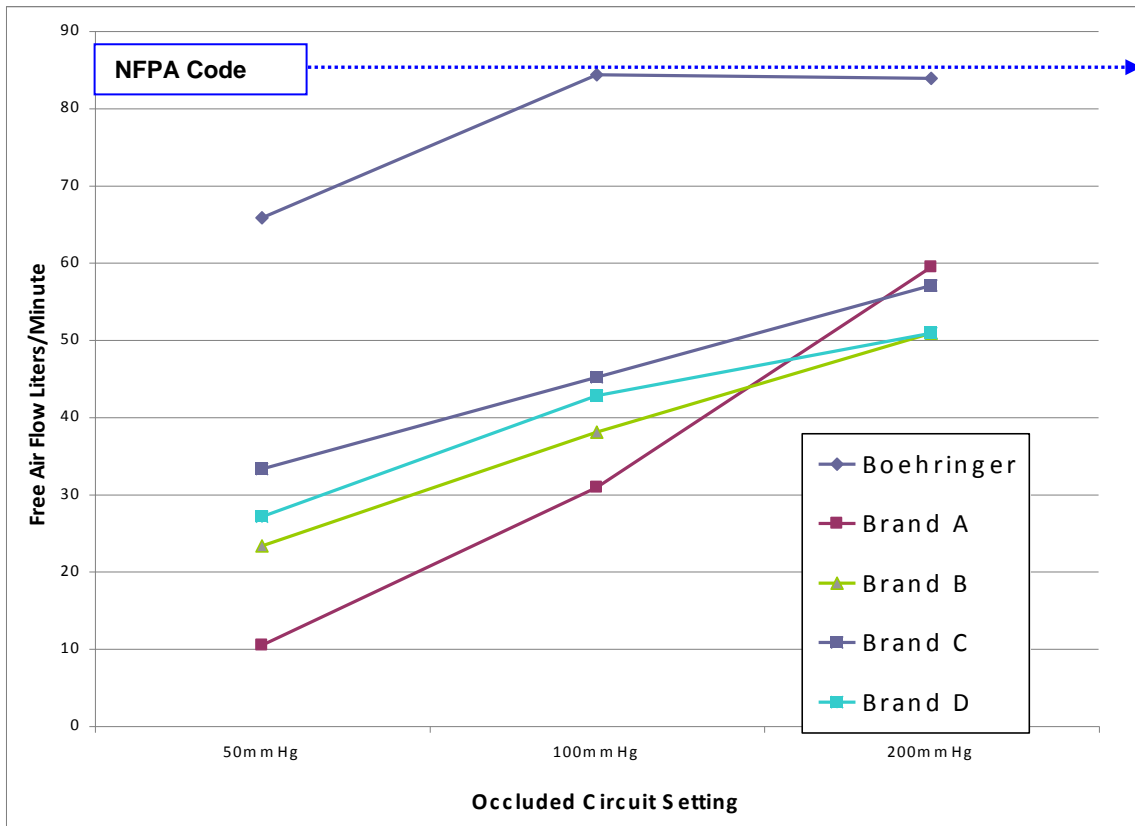
Figure 1

Free Air Flow (Liters per Minute)			
	50mmHg	100mmHg	200mmHg
Boehringer	66	84	84
Brand A	10	31	59
Brand B	23	38	51
Brand C	33	45	57
Brand D	27	43	51

Figure 2

Pressure Setting Required to Provide 66 LPM Flow	
Boehringer	50mmHg
Brand A	150mmHg
Brand B	110mmHg
Brand C	125mmHg
Brand D	100mmHg

Figure 3



Conclusion

Hospital suction outlets need to provide a minimum of 85 liters per minute of free air flow to be compliant with established standards. Suction regulators attached to the wall outlets impose a restriction to the flow available from these outlets.

Except for the Boehringer suction regulators, all other units displayed a linear relation of flow versus pressure. This indicates a design and construction that is inherently restrictive to the system wherein the rate of flow can only be increased by increasing the level of suction applied to the circuit.

Some suction units evaluated as part of this study were unable to provide flow above 20 liters per minute at a setting of 50mmHg. This inability to provide adequate flow at low pressures could preclude the ability to efficiently remove secretions.

The Boehringer regulator provided 66 LPM flow rate at a setting of 50mmHg. To achieve the same performance, the other units compared in this study had to be set between two and three times the desired pressure (100-150mmHg). Clinicians may need to increase suction settings to potentially unsafe levels to achieve flow rates that are comparable to that of the Boehringer regulator. Suction pressure settings above those defined in the clinically recommended guidelines may cause suction-induced trauma to delicate mucosal tissue.

Clinically emergent care situations often require immediate access to high flow suction to remove patient secretions. Only Boehringer suction regulators minimally affect available flow and deliver maximum suction power. This ensures the greatest ability to remove patient secretions at any suction setting.

References

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