Suction devices

Larissa Latif

Jamie Macdonald

Abstract

Suction devices are integral to the safe delivery of anaesthesia and critical care. They are involved in clearing and aspirating body fluids, blood and debris, as well as employed in scavenging waste gases and diathermy fumes, intraoperative cell salvage systems, and tertiary devices such as vacuum mattresses and specialized wound dressings. All suction devices require three essential components, namely a source of vacuum, a reservoir/collection vessel and suction tubing. Other components of a suction device include an on/off switch, a vacuum regulator, vacuum gauge, filters, an overflow safety trap, an overfill protection device in the collection vessel, and a catheter. Several different types of catheter are available for use in different clinical situations. Vacuum and flow are the main physical principles underlying suction devices. The source of vacuum may be a fixed centrally piped system or a portable device using electrical, pneumatic or manual power. Pneumatically powered suction devices utilize the Bernoulli principle and Venturi effect. The efficiency of each system depends upon principles of displacement, degree of negative pressure and time taken to reach this, the internal resistance of the suction apparatus and the viscosity of the material to be aspirated.

Keywords Bernoulli principle; piped vacuum; suction; suction catheters; suction devices; vacuum; venturi effect

Royal College of Anaesthetists CPD Matrix: 1A03, 1C02, 2A01, 2C02

Learning objectives

After reading this article, you should be able to:

- Identify the essential components of a suction device
- describe how a vacuum source is generated for piped and portable suction devices
- recognize how different suction devices may be used in different clinical settings

Suction devices have many applications in anaesthesia and critical care. Suction is used to clear secretions, vomit, blood or debris from the oropharynx and upper airway; via a naso- or orogastric tube to aspirate gastric contents and decompress the stomach; to scavenge anaesthetic waste gases and surgical plume; to clear the surgical field; and for intraoperative cell salvage systems for autologous blood transfusion. Suction can also be applied to chest drains, vacuum mattresses and specialized wound dressings. Suction apparatus must be available and checked prior to every anaesthetic induction and at every bed space in a critical care unit. The Association of Anaesthetists of Great Britain and Ireland (AAGBI) guidelines for checking anaesthetic equipment at the start of every operating session state that suction apparatus must be '*functioning and all connections are secure; test for the rapid development of an adequate negative pressure*'.[1] The UK Government Department of Health (DoH) guidance on building critical care units recommends 2–4 medical vacuum outlets per bed space;[2] this advice is supported by Intensive Care Society guidelines.

Principles of suction

Vacuum and **flow** are the main physical principles underlying suction devices. All such devices require a source of sub-atmospheric pressure which is applied at one end of the system: this creates a pressure gradient which generates a flow through the whole system. The efficiency of a vacuum system is described in terms of the degree of sub-atmospheric pressure achieved, the time taken to reach that pressure, and the displacement or flow rate generated (in litres of air at atmospheric pressure per minute). In practice, the efficiency of a suction system will also be affected by the internal resistance of the entire apparatus and the physical properties of the suctioned material, e.g. viscosity, and the presence of particulate matter.

Vacuum

A true or absolute vacuum is a space entirely devoid of matter, i.e. a pressure of zero. In practice, we tend to refer to any pressure below standard atmospheric pressure as a vacuum or 'negative pressure' and various expressions and units of measurement are used to describe the degree of vacuum (Table 1).

Piped vacuum system

The most common source of sub-atmospheric pressure in a hospital setting is a piped vacuum system comprised of pumps, a reservoir, piping and vacuum inlets.

Multiple electrically-driven, rotary vane pumps which produce a high degree of vacuum and high displacement are used. UK DoH technical specifications state that either three or four pumps should be used; in a triplex system each individual pump must be able to generate the full degree of vacuum for which the system is designed and in a quadruplex system each pump must be able to generate half the desired vacuum. In this way, the central piped system can provide both a primary and secondary supply, allowing for pump servicing and failure. (A tertiary supply, if required, would be provided by portable suction units.)

International standards specify the generation of at least 40 kPa below atmospheric pressure within 10 seconds at the wall inlet, and a minimum flow rate of 20 litres/minute.[3] UK DoH guidance states that the minimum pressure at the central plant/reservoir should be 60 kPa below atmospheric in order to ensure 40 kPa below atmospheric and a flow rate of 40 litres/minute at each wall inlet.[4] The pumps cycle intermittently in

Larissa Latif *MB ChB is a Trainee Anaesthetist at Aberdeen Royal Infirmary, Aberdeen, Scotland, UK. Conflicts of interest: none declared.*

Jamie Macdonald *MB ChB FRCA FFICM is a Consultant Anaesthetist at Aberdeen Royal Infirmary, Aberdeen, Scotland, UK. Conflicts of interest: none declared.*

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Degree of vacuum

Relative vacuum (%)	Residual absolute pressure (bar)	Relative pressure (kPa)	Relative pressure (mmHg)
10	0.9	−10.1	−76
20	0.8	−20.3	−152
30	0.7	−30.4	−228
40	0.6	−40.5	−304
50	0.5	−50.7	−380
60	0.4	−60.8	−456
70	0.3	−70.9	−532
80	0.2	−81.1	−608
90	0.1	−91.2	−684

Table 1

order to maintain the correct degree of vacuum in the reservoir, and this pressure is transmitted via a pipeline system to self-sealing terminal inlets, e.g. wall connection points. Each clinical area must have sufficient wall inlets available: a minimum of one per anaesthetic room, two per operating theatre, two per recovery or ICU bed space and one per emergency department resuscitation bay. If more access points are required, Y-connectors can be used; however, notably this will reduce the degree of vacuum and flow available to each connected device. Vacuum inlets must be non-interchangeable with other piped services; in the UK the suction apparatus is connected by flexible yellow low-pressure hose with a Schrader probe and non-interchangeable indexing collar to a colour-coded wall inlet (Figure 1).

Portable suction

In situations where a medical vacuum inlet is not available, such as during transfers or in the pre-hospital environment, portable suction units may be used. The AAGBI lists portable suction among the essential equipment for pre-hospital anaesthesia.[5] Portable suction units are also recommended for use in clinical areas where the central vacuum system could become contaminated, such as infectious disease units. Sources of vacuum for portable suction units may also be electrically powered (mains or battery) such as rotary or piston pumps, or may be pneumatic or manually driven. Separate international standards govern the use of each.

Pneumatically powered pumps utilize Bernoulli's principle and the Venturi effect. Bernoulli's principle describes the conservation of energy in a flow of fluid (liquid or gas) passing through a constriction: an increase in kinetic energy (fluid velocity) is associated with a decrease in potential energy (pressure). As per the Venturi effect, introduction of an aperture or, in the case of suction systems, a side-arm just distal to the constriction causes entrainment of material due to the pressure gradient across the aperture or side arm (Figure 2). However, pneumatically driven vacuum generators are recommended only for emergency use, as these units generally utilize medical oxygen and use large amounts of gas. This can lead to oxygen enrichment and present a potential fire hazard and may result in the emission of microbially contaminated material, as well as being wasteful.

Figure 1 Suction vacuum wall inlet.

Manually powered vacuum systems generally consist of a spring-loaded bellows with unidirectional valves which may be hand or foot operated. A very simple manual suction device can be created by attaching a syringe to a suction catheter.

Suction apparatus

Components of a suction device, other than a source of vacuum, include:

- an on/off switch
- a vacuum regulator
- vacuum gauge
- filters
- an overflow safety trap
- a reservoir (collection container) with overfill protection device
- tubing, and
- a catheter.

In most hospital suction devices, the first five of these components are arranged together in a control box as in Figure 3 and Figure 4. The vacuum regulator controls the amount of suction by allowing a variable amount of air to bleed into the system.

The **reservoir** is a container that collects the suctioned material and is usually graduated so that the volume of aspirate can be measured. Most reservoirs have a disposable plastic liner to facilitate emptying and cleaning. The lid of the container must be well fitting to prevent leaks and maintain the generated vacuum. The reservoir needs to be sufficiently large to contain the expected amount of aspirate, but this must be balanced against the fact that larger volume reservoirs will take longer to reach the required vacuum.

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