

ORIGINAL SCIENTIFIC PRESENTATION

Vacuum Pressures During Autologous Fat Transfer (AFT): A Study of the Closed Syringe Type and Other Aspirator Pressures

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Objective: Vacuum pressures have long been thought to damage the lipocytes during harvest. Several studies have described this as well as the need to reduce the pressure during harvest. The goals of this article are to increase awareness of the pressures associated with the closed syringe technique and other methods of harvesting for autologous fat transfer (AFT).

Methods: The closed syringe pressures are presented for 60-, 30-, and 10-mL syringes. Note that the vacuum force for any manual syringe is the plunger and the position of the plunger will dictate the pressure that will be applied to the fat.

Results: The closed syringe tests on 60-, 30-, and 10-mL syringes (three brands) show that a 60-mL syringe will produce an 18.5-in mercury vacuum pressure, but only when the plunger is withdrawn to maximum. The tests also showed that when the plunger is at 30 mL, the response is 16 in of mercury; at 10 mL the response is 6 in of mercury. Thus, the smaller the syringe capacity, the lower the vacuum pressure. This lessening of the vacuum pressure is not due to the plunger losing pressure around its gasket, but it is directly related to the empty space (volume) left in the syringe. Thus, a 60-mL syringe that is half full of fat renders an identical pressure to an empty 30-mL syringe, that being 16 in of mercury.

Discussion: Electrically powered vacuum sources do not respond in this manner because the motor will maintain a relatively constant pressure throughout the procedure. The economic advantages of the closed syringe technique are discussed with emphasis on the availability of generic

materials and thus lessened cost. The disadvantages include the varying downward pressures during harvest, the added time to decant or centrifuge the harvested material, and the need for added transfers. Also presented are the 2 filter-type harvest units on the market today (Lipivage and TissuTrans) that will save considerable time by separating out the unwanted material during the harvest and without additional transfers.

Conclusion: Knowing the pressures administered (to fat) by the syringes or reservoirs used in all types of fat harvesting equipment is important and part of the standardization process.

Because vacuum pressure has the capacity to destroy fat cells^{1,2} during autologous fat transfer (AFT) harvest, it is important to know the pressures AFT harvest devices render on the fat during the AFT procedure. The objective of this article is to (1) increase awareness of the pressures the fat is encountering when the fat is harvested with the closed syringe technique, (2) increase awareness of other improved sources that can be used efficiently for fat harvest during AFT, and (3) increase awareness of 2 time-saving syringe-type filter products that are available for AFT.

Definitions

- **Closed syringe technique:** A method of removing fat from the donor site using the power of the plunger retracted inside a closed space (syringe).
- **Aspirator technique:** A method of removing fat from the donor site using the power of an aspirator.
- **Centrifuge technique:** A method of removing the unwanted portion of a fat harvest via a centrifuge.

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- *Decantation technique:* A method of removing the unwanted portion of fat harvest via decanting.
- *Filter technique:* A method of removing the unwanted portion of fat harvest via a filter.
- *AC-powered aspirators:* Aspirators that have alternating current power.
- *DC-powered aspirators:* Aspirators that have direct current (battery) power.
- *Wall suction:* Aspirators that are installed behind a wall with only the coupler visible on the operating room wall. Because of the distance from the site of fat aspiration and the varied diameters of the tubing, the unit usually administers 22 to 25 in of mercury.
- *Atmospheric pressure below and at sea level:* At sea level, high-grade aspirators are capable of administering vacuum at 29.5 in of mercury, the maximum. However, above sea level the capability goes down significantly. The general rule of thumb is 1 in less of mercury (from a maximum of 29.5 in) for every 1000 ft above sea level. Thus, in Denver, Colorado, which is a mile above sea level, the maximum aspiration power is about 24 in of mercury.

Methods

The closed syringe technique is usually performed with standard sterile 60-mL, 30-mL, or 10-mL syringes of the BD (Becton Dickinson, Franklin Lakes, NJ), Monoject (Covidien/Kendall Healthcare, Mansfield, MA), or Medallion (Qosina, Edgewood, NY) Brands. These sizes and brands were tested (Figure 1A).

All 9 syringes were tested in an identical manner. The plungers were first pushed all the way into the syringe cavity and the Luer tip connected to a standard calibrated manometer. With this connection there was no notable ambient air in the syringe, so that when the plunger was pulled outward the pressure in inches of mercury was registered on the manometer (Figure 1B).

Closed Syringe and Pressure Measurement at Maximum Vacuum

The plunger was then pulled outward to maximum capacity of the syringe. Thus, the 60-mL syringe plunger was pulled out to the 60-mL mark, the 30-mL plunger was pulled out to the 30-mL mark, and the 10-mL plunger was pulled out to the 10-mL mark. A reading was then taken from the manometer and recorded as the maximum vacuum pressure in that

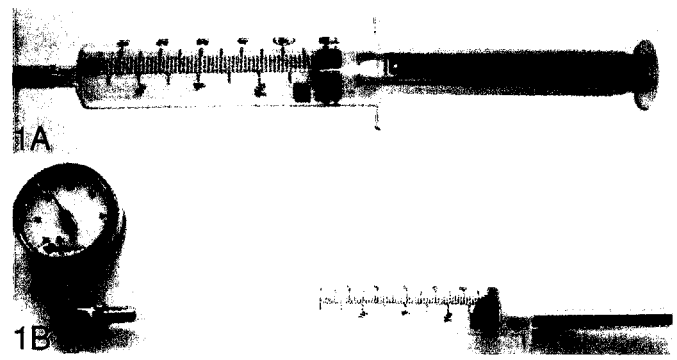


Figure 1. 1A: Closed syringe with lock adjacent plunger. 1B: The manometer test unit is a simple setup of a syringe connected to a manometer.

syringe. This was then repeated with each of the three brands (Table 1).

Closed Syringe and Pressure Measurement at One Half of the Maximum Vacuum Pressure

The plunger was then pulled outward to one half of the maximum capacity of the syringe. Thus, the 60-mL syringe plunger was pulled out to the 30-mL mark, the 30-mL plunger was pulled out to the 15-mL mark, and the 10-mL plunger was pulled out to the 5-mL mark. A reading was then taken from the manometer and recorded as one half of the maximum vacuum pressure in that syringe. This was then repeated with each of the three brands (Table 1).

Closed Syringe and Pressure Measurement at One Third of Maximum Vacuum Power

The plunger was then pulled outward to one third of the maximum capacity of the syringe. Thus, the 60-mL syringe plunger was pulled out to the 20-mL mark, the 30-mL plunger was pulled out to the 10-mL mark, and the 10-mL plunger was pulled out to the 3.3-mL mark. A reading was then taken from the manometer and recorded as one third of the maximum vacuum pressure in that syringe. This was then repeated with each of the three brands (Table 1).

Pressure Measurements of Wall-type Suction Units

Wall-type suction units, which are typically used in hospitals, free-standing operating rooms, and private operating room suites, have adjustable vacuum pressures and only the maximum pressures are important. The maximum pressures are well known in the industry, thus no measurements were taken. The maximum

Table 1. Syringe Pressures Relative to Volumes

Device Tested	Vacuum at Maximum Volume in Inches of Mercury	Vacuum at One-half Volume in Inches of Mercury	Vacuum at One-third Volume in Inches of Mercury	Comments
60-mL syringe				
BD	18.5	16.0	14.0	The vacuum power decreased in relation to the open volume left in the syringe
Monoject	18.5	16.0	14.0	
Medallion	18.5	16.0	14.0	
30-mL syringe				
BD	16.0	13.0	10.0	The vacuum power decreased in relation to the open volume left in the syringe
Monoject	16.0	13.0	10.0	
Medallion	16.0	13.0	10.0	
10-mL syringe				
BD	10.0	6.0	3.0	The vacuum power decreased in relation to the open volume left in the syringe
Monoject	10.0	6.0	3.0	
Medallion	10.0	6.0	3.0	

vacuum power can only be achieved at sea level. Manometers should be calibrated at periodic intervals recommended by the manufacturer (Table 2).

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Pressure Measurements with AC Mobile Units

Table 2 presents results for AC mobile units, the units most commonly used by liposuction surgeons. These were not measured because the information is available from the companies manufacturing them. The maximum vacuum power can only be achieved

Table 2. Wall and Floor Aspirator Pressures

Device	Vacuum at Maximum Volume in Inches of Mercury	Vacuum at One-half Volume in Inches of Mercury*	Comments
Wall suction at local surgical center	24 to 29.5 adjustable	N/A	Findings vary considerably but most are around 24 in of mercury
Wall suction at local hospital	23 to 29.5 adjustable	N/A	Findings vary considerably but most are around 24 in of mercury
Wall suction at private local operating room	23 to 29.5 adjustable	N/A	Findings vary considerably, but most are around 24 in of mercury
Standard liposuction aspirators	Up to 29.5 adjustable	N/A	Findings vary considerably, but most can reach maximum at sea level
Small electrical units and battery-powered aspirators	Maximum 20 to 24, even at sea level	N/A	These are the lesser powered units that are used in emergency vehicles and in clinics

*N/A indicates not applicable.

maximum position. It is conventionally thought that a fully withdrawn plunger will maintain the pressure at maximum throughout the procedure, but this is not what happens. As the syringe fills with harvested fat, the pressure will go down in accordance with the empty volume left in the syringe, which in turn slows the procedure considerably. Thus, if a 60-mL syringe is half full of fat, the fat occupying the space has essentially converted the 60-mL syringe (functionally) into a 30-mL syringe, with its lessened pressure and speed.

Discussion

Vacuum pressures have long been thought to cause substantial damage to the lipocytes during harvest, and several articles have described this damage and the need to reduce the pressure to prevent lipocyte damage.³⁻⁶ Most surgeons now agree that harvesting for AFT should be performed at a vacuum pressure of 15 to 20 in of mercury to prevent damage to the lipocyte.^{1,2,9} Most surgeons agree that to develop the procedure to an upgraded "take" result level, the instruments and techniques must be standardized^{1,7,8} and additives^{7,9} will be needed. However, most surgeons do not agree on which instruments, techniques, or additives will accomplish this goal.¹

The Closed Syringe Technique

Many surgeons use the closed syringe technique^{8,14} when harvesting fat, especially for facial filling and small body areas (Figure 1). The instruments are simple and economical, and the syringes operate at a maximum vacuum pressure of 18.5 in (Table 1) of mercury with a gradual decrease in this pressure down to 3 in of mercury during harvest. The use of the closed syringe with a cannula attached directly means that the fat has to pass through only one coupler (Luer) and no tubing, further lessening the potential for trauma to the lipocyte. The way the unit is constructed encourages standardization because the only possible notable variable is the cannula. This variability can be avoided by using the same cannula and hole pattern each time and keeping transfers to a minimum.

However, the down side of the closed syringe technique is the lack of speed as the syringe fills with fat. If only a small amount of fat is needed for the transfer this is not an issue. However, as the needed volume increases, speed becomes an issue. Even though the closed syringe plunger is fixed with a type of lock, the

Results

The closed syringe tests on 60-, 30-, and 10-mL syringes (3 brands) showed that a 60-mL syringe will produce an 18.5-in mercury vacuum pressure, but only when the plunger is withdrawn to maximum. The tests also showed that when the plunger is at 30 mL, the response is 16 in of mercury; at 10 mL the response is 6 in mercury. Thus, the smaller the syringe capacity, the lower the vacuum pressure.

If a surgeon uses a closed 60-mL syringe (any brand) a lock is usually used to keep the plunger at its

effect of adding fat to the closed syringe is exactly the same as allowing the plunger to advance in the syringe. As the open space in the syringe fills with fat, the pressure gradually drops down to a nonfunctional level of about 3 in of mercury (Table 1). All of the other types of available vacuums allow the surgeon to adjust the manometer to an AFT acceptable level and maintain that level of vacuum throughout the procedure.

Wall Suction Units

Many surgeons use wall suction units to supply the vacuum for harvesting fat (Table 2). Because the aspirator supplies more than one operating room with suction, these units are located quite a distance from the patient being treated. These suction units, because of the distance from the patient and the varied tubing sizes, can usually only provide about 22 in of mercury pressure even at sea level.

Direct Current Units

DC units are portable and are the ones usually found in emergency vehicles. They are not usually used for liposuction and fat harvest because of additional battery costs, but because they can render up to 24 in of mercury, they could be used to perform such procedures.

Alternating Current Units

Most of the units that are used for liposuction and fat transfer are portable units powered by an AC motor. When using these units as a vacuum source for fat transfer it is customary to lower the pressure to 15–20 in of mercury because higher pressures damage the fat harvest.^{1,2,9} These AC units, which are sold by Wells Johnson, Klein Medical, Byron Mentor, Kolster Methods Inc, MD Resources, and Shippert Medical Technologies, are very reliable. They produce a vacuum of 29.9 in of mercury at sea level and reduce in power by 1 in of mercury for every 1000 ft in elevation.

Table 4. Equivalent Pressures

Inches of Mercury	Millimeters of Mercury	Centimeters of Mercury
30	760	76.0
20	508	50.8
15	381	38.1
10	254	25.4
5	127	12.7

Specialized Filter Syringes

Two types of harvesting filter syringe devices are available on the market that use AC power. The pressure in these units is constant at the level set by the surgeon. A reduced pressure of 15 to 20 in of mercury is usually preferred to lessen damage to the lipocytes.^{1,2,9}

These units will filter the fat, removing the unwanted portion while the fat is being harvested. This eliminates the time it usually takes to centrifuge or decant, which is at least 20 minutes. The units have a varied volume capacity but are reasonably efficient in separating out the unwanted material from the fat.

Conclusion

Knowing the approximate vacuum pressures of the various devices used during fat harvest for autologous fat grafting is important. In general the closed syringe used in the closed syringe technique administers pressures of less than 18.5 in of mercury, which is ideal for fat grafting. When using closed syringes the actual pressure is dependent on the vacant capacity of the syringe and the larger the capacity the greater the

vacuum pressure with an upper limit of 18.5 in of mercury. The powered methods of vacuum harvest such as seen with wall suction or portable floor models, have the capacity to administer up to 29.5 in of mercury at sea level and decreases approximately 1 in for every thousand feet of elevation above sea level. Most surgeons will turn this vacuum pressure down to 15 to 20 in of mercury for harvesting the fat.

Acknowledgment

Dr. Shippert is the owner of Shippert Medical Technologies, a company that supplies innovative products for the plastic surgery market. He writes about product features and compares products in the marketplace. All products are tested by the same parameters, and results are presented without preferences so that the cosmetic surgeon can make informed decisions.

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