3 Introduction to Needles and Cannulae

Theodore R. Kucklick

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One of the most common materials used in medical devices is small-diameter (hypodermic) stainless steel tubing. One of the most common medical devices is the hypodermic needle. Another is the suturing needle, and others include trocars and cannulae. Needles and cannulae have been used in medicine since the dawn of recorded history. The ancient Egyptians used metal tubes to gain access to the bladder and other structures. Needles are used for a wide variety of functions, such as injection, suturing, biopsy, gaining access to a surgical space, delivery of radio frequency (RF) energy for tissue ablation, delivery of electrical impulses for evoked potential tests, holding thermocouples for temperature measurement, guiding other devices such as guidewires and catheters, and numerous other applications.

A typical needle works by piercing tissue with its sharp point and then smoothly slicing through tissue with its sharpened edges. The needle is usually designed to penetrate tissue with the least amount of resistance, thus causing minimal disruption to tissue. The sharpness of the needle as well as the polish of the tubing and freedom from burrs and roughness contribute to the effectiveness of the needle to penetrate tissue with the least resistance and to cause a minimum of tissue damage and discomfort.

**NEEDLE GAUGES AND SIZES**

There are several (confusing and mutually incompatible) ways to measure hypodermic needle diameter. The first is needle gauge. This is based on the Stubs wire gauge. Other methods include the French catheter gauge, metric sizes in millimeters, or decimal or fractional English units.

**Gauge Size**

Hypodermic tubing is commonly sized according to the English Birmingham or Stubs iron wire gauge.¹ Note that this is not the same as the Brown and Sharpe or the W&M music wire gauge.

In the Stubs wire gauge world, as the gauge number goes up, the size goes down. This is because the gauge number was originally based on a 19th-century standard of approximately how many times the wire was drawn to get smaller sizes. The more draws, the smaller the wire and the higher the gauge number. This means that there is no number that adds up to a gauge. In most cases, the gauge became based on a geometric constant, and each manufacturer had its own. In the Stubs iron wire system, which is used to measure hypodermic tubing, a 10-gauge is 0.134 inch, and a 20-gauge is 0.035 inch. The Stubs gauge was originally developed in the late 1800s² and continues to be used as a matter of convenience and convention.
Obtaining a reference chart of gauge and decimal needle sizes from your tubing vendor is very helpful. Certain gauge sizes have become commonly used in medicine (e.g., the 22-gauge needle for venipuncture). It has become a convenient way for practitioners to remember needle sizes as opposed to a fractional or decimal measurement, but otherwise it is quite counterintuitive.

The other thing to remember about gauge size is that this measurement refers to *outside diameter* (OD). Inner diameter (ID) is measured in English or metric diameter.

**French Catheter Size**

A French is a unit of linear measure; 1 French is equal to one-third of a millimeter (making it somewhat incompatible with the base 10 metric system). French size is abbreviated Fr. French size measures the circumference, not the diameter, of a catheter; 3 Fr = 3 mm circumference and approximately 1 mm diameter. The French size, for example, is not the diameter of a catheter with an oval cross section at its widest point. The name and the symbol Ch refer to the Charrière gauge scale, which is often called the French scale. ³

This makes the French scale useful for measuring catheters that are not round. Think of it as the way you measure around your waist to get your pant size. Because most catheters are round, the French size in diameter is fairly consistent, even though this is not really what is being measured.

French is usually used when describing the diameter of flexible catheters, or larger tubes. On medical packaging French is often abbreviated F (e.g., 10F).

**Metric and English**

In Europe and Asia, needle sizes and catheter sizes tend to be described in metric units, according to the diameter, either OD or ID. Engineers tend to describe diameters in either decimal English or metric units, according to their preference, and then translate these sizes into the units used by the medical professionals with whom they are dealing (see Table 3.1).

**Working with Hypodermic Tube**

When working with hypodermic medical tubing, it is especially important to know how the tubing is made, especially if an assembly is being designed for which an obturator, stylet, catheter, wire, tube, or rod is being designed to fit into the tube’s ID.

The first consideration is this: tubing is made by reducing the OD of the tube through a die. This means that the OD is controllable. The ID of the tube then becomes a function of the OD minus the nominal wall thickness of the tube after forming. This means that the ID is not absolutely controlled. The ID is a theoretical number. This can be seen in the accompanying illustration (see Figure 3.1). This must be taken into account when calculating tolerances between the ID of the tube and whatever you are designing to slide into the tube.
It is possible to draw tubing over a mandrel of a precise size or hone the ID; however, this is more expensive than using readily available standard-size hypotube.

Also, when designing a part to fit in to the inner lumen of a hypotube, remember that tubes are never perfectly round, perfectly straight, or perfectly smooth on the inside. All of these factors will affect how much tolerance to allow in order to fit a part into the hypotube lumen.

If you are planning to insert a long part into a long hypotube, remember to allow enough tolerance. Even if a part fits easily into a short section of tube, frictions and tolerance stack-ups rapidly accumulate. In this situation, a part may fit initially, but then become jammed as the part is advanced through the full length of the tube.

<table>
<thead>
<tr>
<th>Gauge Number</th>
<th>Metric (mm)</th>
<th>French Catheter (Fr. (mm × 3)</th>
<th>Stubs Gauge</th>
<th>American (A.W.G.) or Brown and Sharpe (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5.16</td>
<td>15.5</td>
<td>0.203</td>
<td>0.1620</td>
</tr>
<tr>
<td>7</td>
<td>4.57</td>
<td>13.7</td>
<td>0.180</td>
<td>0.1442</td>
</tr>
<tr>
<td>8</td>
<td>4.19</td>
<td>12.6</td>
<td>0.165</td>
<td>0.1284</td>
</tr>
<tr>
<td>9</td>
<td>3.76</td>
<td>11.3</td>
<td>0.148</td>
<td>0.1144</td>
</tr>
<tr>
<td>10</td>
<td>3.40</td>
<td>10.2</td>
<td>0.134</td>
<td>0.1018</td>
</tr>
<tr>
<td>11</td>
<td>3.05</td>
<td>9.2</td>
<td>0.120</td>
<td>0.0907</td>
</tr>
<tr>
<td>12</td>
<td>2.77</td>
<td>8.3</td>
<td>0.109</td>
<td>0.0808</td>
</tr>
<tr>
<td>13</td>
<td>2.41</td>
<td>7.2</td>
<td>0.095</td>
<td>0.0719</td>
</tr>
<tr>
<td>14</td>
<td>2.11</td>
<td>6.3</td>
<td>0.083</td>
<td>0.0640</td>
</tr>
<tr>
<td>15</td>
<td>1.83</td>
<td>5.5</td>
<td>0.072</td>
<td>0.0570</td>
</tr>
<tr>
<td>16</td>
<td>1.62</td>
<td>5</td>
<td>0.065</td>
<td>0.0508</td>
</tr>
<tr>
<td>17</td>
<td>1.47</td>
<td>4.4</td>
<td>0.058</td>
<td>0.0452</td>
</tr>
<tr>
<td>18</td>
<td>1.27</td>
<td>3.8</td>
<td>0.049</td>
<td>0.0403</td>
</tr>
<tr>
<td>19</td>
<td>1.07</td>
<td>3.2</td>
<td>0.042</td>
<td>0.0358</td>
</tr>
<tr>
<td>20</td>
<td>0.91</td>
<td>3.7</td>
<td>0.035</td>
<td>0.0319</td>
</tr>
<tr>
<td>21</td>
<td>0.82</td>
<td>3.4</td>
<td>0.032</td>
<td>0.0284</td>
</tr>
<tr>
<td>22</td>
<td>0.72</td>
<td>2.7</td>
<td>0.028</td>
<td>0.0253</td>
</tr>
<tr>
<td>23</td>
<td>0.64</td>
<td>2.2</td>
<td>0.025</td>
<td>0.0225</td>
</tr>
<tr>
<td>24</td>
<td>0.57</td>
<td>1.7</td>
<td>0.022</td>
<td>0.0201</td>
</tr>
<tr>
<td>25</td>
<td>0.51</td>
<td>1.5</td>
<td>0.020</td>
<td>0.0179</td>
</tr>
<tr>
<td>26</td>
<td>0.46</td>
<td>1.3</td>
<td>0.018</td>
<td>0.0159</td>
</tr>
<tr>
<td>27</td>
<td>0.41</td>
<td>1.2</td>
<td>0.016</td>
<td>0.0141</td>
</tr>
<tr>
<td>28</td>
<td>0.36</td>
<td>1</td>
<td>0.014</td>
<td>0.0126</td>
</tr>
<tr>
<td>29</td>
<td>0.34</td>
<td>—</td>
<td>0.013</td>
<td>0.0112</td>
</tr>
<tr>
<td>30</td>
<td>0.31</td>
<td>—</td>
<td>0.012</td>
<td>0.0100</td>
</tr>
<tr>
<td>31</td>
<td>0.26</td>
<td>—</td>
<td>0.010</td>
<td>0.0089</td>
</tr>
<tr>
<td>32</td>
<td>0.23</td>
<td>—</td>
<td>0.009</td>
<td>0.0079</td>
</tr>
</tbody>
</table>
When measuring tubing with a pin gauge, be sure that the end of the tube is free from burrs. Deburring the end of the tube with a 60-degree cone burr held in a pin vise is a convenient way to clean up a tube before measuring. Also, remember that a gauge pin the exact diameter of the tube will not fit in the tube. For example, a 0.125 inch pin will not fit in a 0.125 inch lumen.

**COMMON HYPODERMIC TUBING MATERIALS**

The most common hypodermic tubing material is 300 series stainless; 400 series stainless is required for heat treating. Nickel–titanium tubing is also now readily available from vendors, such as Memry Corporation (Bethel, CT) and Nitinol Devices Corporation (NDC; Fremont, CA). Tubing of other alloys, such as titanium, is available for use in magnetic resonance imaging (MRI) radiology applications.

If you look at a hypodermic needle, you will notice that the end is not ground to a simple bevel. Hypodermic needles are usually ground with a compound bevel, typically called a lancet point, and the angles of these bevels give the needle its characteristics (see Figure 3.2). Some needles are designed to pierce veins and arteries, others to penetrate into muscle, and yet others to penetrate tough fascia and joint capsule tissue (see Table 3.2).

**R&D NEEDLE GRINDING**

Glendo Corporation (Emporia, KS) makes a versatile grinder that works very well for grinding prototype sharps. It is a low-heat slow-resolution per minute (slow-rpm) diamond grinder originally designed to sharpen carbide tools (see Figure 3.3).
A simple fixture can be made for grinding prototype lancet sharps. Here are the general specifications:

Take a block of Delrin or other abrasion-resistant plastic and mill two surfaces as shown. These establish the angle of the first main bevel and the secondary bevels. Next, drill two holes through the block perpendicular to these planes. Note: The length of these holes needs to be equal so that when the second bevels are ground, they form a point and do not obliterate the first bevel. The grinds need to meet at the point. The angle of the secondary bevel must be steeper than the first bevel to form a lancet point.

Next, drill holes for the index pin. It will be at the 12:00 position, as shown in Figure 3.4, for the primary bevel, and at approximately the 11:00 and 1:00 positions for the secondary bevels, depending on the desired angle of rotation for the secondary bevels. Next make an index pin holding collar and mount it to a pin vise. Insert an index pin as shown in Figure 3.4. When the hypotube is held in the pin vise, this will index the angles of rotation for the bevels.

To grind a needle, place the pin vise in the index hole for the first bevel, and slide the hypotube through the pin vise and the fixture block for the first bevel. With just enough tube sticking out to grind the bevel, tighten the pin vise and grind the first bevel. The Glendo™ grinder works well for this application. Next, move the tube to the secondary bevel grinding position. The tip of the first bevel should sit right at the edge of the hole for the second bevel, with a slight overlap to ensure a complete sharp-tip grind. Insert the index pin into the 11:00 position and grind the first secondary bevel; then move the pin to the 1:00 position and grind the next secondary bevel. The heel of the needle should then be dulled with a small fine-grained grindstone if tissue coring is to be prevented.

With this fixture setup, it is simple to make a set of blocks for a variety of combinations of first bevel angle, second bevel angle, and angle of rotation for the secondary bevels. Once proof of concept is achieved, one of the vendors listed in the Resources section at the end of this chapter can produce your needles in volume under good manufacturing practice (GMP) guidelines or can supply an off-the-shelf version.
TABLE 3.2
Basic Types of Needles and Typical Applications

<table>
<thead>
<tr>
<th>Bevel Type</th>
<th>Gauge Range (approximate)</th>
<th>Bevel Angle (degrees)</th>
<th>Mean Bevel Angle (degrees)</th>
<th>Typical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>7–12</td>
<td>15–17</td>
<td>12</td>
<td>Subcutaneous and intramuscular injection</td>
</tr>
<tr>
<td></td>
<td>13–16</td>
<td>13–14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17–21</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22–27</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28–33</td>
<td>13–14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intravenous</td>
<td>15–18</td>
<td>12–14</td>
<td>13</td>
<td>Disposable IVs</td>
</tr>
<tr>
<td>Medium</td>
<td>13–16</td>
<td>16–17</td>
<td>15</td>
<td>Subcutaneous IV and intramuscular injection</td>
</tr>
<tr>
<td></td>
<td>16–18</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>10–12</td>
<td>23–25</td>
<td>19</td>
<td>Nerve block, IV intra-arterial</td>
</tr>
<tr>
<td></td>
<td>13–16</td>
<td>19–22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17–21</td>
<td>18–19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22–27</td>
<td>15–19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arterial</td>
<td>15–17</td>
<td>21–22</td>
<td>20</td>
<td>Intra-arterial injection</td>
</tr>
<tr>
<td></td>
<td>18–20</td>
<td>18–19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinal</td>
<td>7–12</td>
<td>26–31</td>
<td>22</td>
<td>Spinal anesthesia</td>
</tr>
<tr>
<td></td>
<td>13–16</td>
<td>23–25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17–21</td>
<td>18–22</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22–30</td>
<td>15–17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intradermal</td>
<td>26</td>
<td>23.5</td>
<td>23.5</td>
<td>Intradermal</td>
</tr>
<tr>
<td>Regular Quincke</td>
<td>—</td>
<td>22</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Short Quincke</td>
<td>—</td>
<td>30</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pitkin</td>
<td>—</td>
<td>45</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Source: Courtesy of Popper and Sons, Inc., New Hyde Park, NY.

SUTURE NEEDLES

Curved suture needles, very similar to needles used in the 21st century, were first used in ancient India. Other shapes of needles are straight needles, which are less commonly used for suturing, the common curved needle, the half-curved ski needle, and the compound curved needle for specialty applications, such as microvascular surgery (see Table 3.3).

* For an introductory article on sutures and needles, see Steven Lai and Daniel Becker, “Sutures and Needles,” Medscape Reference, http://www.emedicine.com/ent/topic38.htm, which provides a detailed overview describing many of the important parameters in needle and suture selection.

FIGURE 3.3 Glendo Accu-Finish® grinder. (Glendo, Inc., Emporia, KS.)

FIGURE 3.4 Prototype needle grinding fixture.
### TABLE 3.3
Suture Needle Identification Chart

<table>
<thead>
<tr>
<th>Needle Type</th>
<th>Description</th>
<th>Point Shape(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular trocar point</td>
<td>A round bodied needle with triangle cutting edges</td>
<td>![trocar point]</td>
</tr>
<tr>
<td>Regular taper point</td>
<td>A round-tapered point needle</td>
<td>![taper point]</td>
</tr>
<tr>
<td>Regular taper cutting</td>
<td>A round-tapered point needle with short cutting edges</td>
<td>![taper cutting]</td>
</tr>
<tr>
<td>Regular reverse cutting edge</td>
<td>A triangle cutting edge needle</td>
<td>![reverse cutting]</td>
</tr>
<tr>
<td>Regular diamond point</td>
<td>A side cutting needle</td>
<td>![diamond point]</td>
</tr>
<tr>
<td>Regular conventional cutting edge</td>
<td>An inside apex triangle cutting edge needle</td>
<td>![conventional cutting]</td>
</tr>
<tr>
<td>Regular blunt taper point</td>
<td>A blunt-tapered point needle</td>
<td>![blunt taper]</td>
</tr>
<tr>
<td>Regular ball point</td>
<td>A blunt point needle</td>
<td>![ball point]</td>
</tr>
<tr>
<td>Premium lancet point</td>
<td>A hand-honed side cutting needle</td>
<td>![lancet point]</td>
</tr>
<tr>
<td>Premium diamond point</td>
<td>A hand-honed side cutting needle</td>
<td>![diamond point]</td>
</tr>
<tr>
<td>Premium cutting edge</td>
<td>A hand-honed triangle cutting edge needle</td>
<td>![cutting edge]</td>
</tr>
<tr>
<td>Cardiovascular (CV)</td>
<td>A round-tapered point, square bodied needle</td>
<td>![CV]</td>
</tr>
</tbody>
</table>

*Source:* Courtesy of BG Sulzle, Inc., N. Syracuse, NY.
The most important feature of a suture needle is that it passes through tissue, causing the least amount of trauma. It is also important that the needle pass through smoothly. Some needles are coated with silicone or other lubricious coating. The needle must be of a material that will hold its shape while being passed through tissue, hold a sharp point or edge, and not be so hard that the needle becomes brittle and prone to breakage. Suture needles are driven through tissue with needle holders. Some needle holders have special carbide inserts in the jaws to provide extra grip on the needle while driving the needle through tough tissue.

**BASIC TYPES OF SUTURE NEEDLE TIPS**

**Conventional Cutting**
In a conventional cutting configuration, there are three cutting edges, with one cutting edge facing the inside of the needle arc. This is known as a surface-seeking needle.

**Reverse Cutting**
Reverse-cutting needles cut on two sides and have the third cutting edge on the outside of the needle arc. This is known as a depth-seeking needle.

**Side Cutting**
Side-cutting needles, or spatula needles, have two cutting edges perpendicular to the arc of the needle. These are used for ophthalmic procedures.

**Taper Point**
A taper point is similar to a regular sewing needle. The sharpness is determined by taper ratio and tip angle. The needle is sharper if it has a higher taper ratio and lower tip angle. The taper-point needle is used for easily penetrated tissues, such as abdominal viscera and subcutaneous tissue, and minimizes potential tearing of tissue.

**Blunt Point**
Blunt needles dissect, rather than cut, tissue. Blunt needles are used to suture friable tissue, such as liver.

**SUTURE ATTACHMENT METHODS**

**Swaging Sutures to Needles**
A swaging suture is usually permanently swaged to the needle. Needles with sewing needle-style eyelets require two strands of suture, which causes more tissue damage as the double strand is passed through tissue.
**DRILL**

In a drill suture the proximal end of the needle is drilled with a hole, and the needle is swaged to retain the suture. This makes the proximal end smaller than the needle body.

**CHANNEL**

In the channel method, the end of the needle is formed into a channel, and the needle is crimped to retain the suture. In this case, the proximal end becomes larger than the needle body.

**NONSEWAGED, CLOSED EYE, FRENCH EYE, SLIT, SPRING**

Various methods to retain the suture include nonswaged, closed eye, French eye, slit, and spring sutures. These methods have the disadvantage of pulling a double strand of suture through the tissue.

**SUTURE SIZES**

Sutures are sized in the United States according to a system from the U.S. Pharmacopoeia (USP). Sutures are gauged not only by diameter, but also by tensile strength and knot security. Sutures sizes are measured on two scales:

1. A whole number system for larger sutures, from 5 (largest) to 0 (smallest).
2. A composite number system for smaller sutures (smaller than 0), from 1–0 (largest) to 12–0 (smallest). These are the “aught” sizes (e.g., 12–0 is pronounced 12-aught or 12-oh).

The following chart of suture sizes lists the largest sizes on the left and the smallest microsurgery sizes on the right:

<table>
<thead>
<tr>
<th>Larger</th>
<th>Smaller</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>12–0</td>
</tr>
<tr>
<td>4</td>
<td>11–0</td>
</tr>
<tr>
<td>3</td>
<td>10–0</td>
</tr>
<tr>
<td>2</td>
<td>9–0</td>
</tr>
<tr>
<td>1</td>
<td>8–0</td>
</tr>
<tr>
<td>0–0</td>
<td>7–0</td>
</tr>
<tr>
<td>1–0</td>
<td>6–0</td>
</tr>
<tr>
<td>2–0</td>
<td>5–0</td>
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<td>3–0</td>
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<td>4–0</td>
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<td>5–0</td>
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<td>9–0</td>
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<tr>
<td>9–0</td>
<td>10–0</td>
</tr>
<tr>
<td>10–0</td>
<td>11–0</td>
</tr>
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<td>11–0</td>
<td>12–0</td>
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Various types and sizes of suture needles are illustrated in Figure 3.5.

Although European suture is measured in diameter, two sutures of the same size can be very different in tensile strength. The USP system tries to rank suture gauge so that two sutures of the same gauge will have similar tensile strength.

**SUTURE TYPES**

There are two basic categories of suture material, natural and synthetic. There are two basic types of performance characteristics, absorbable and nonabsorbable. Suture is constructed in either braided or monofilament forms.
Natural Absorbable

Natural absorbable sutures include gut (made from sheep or beef intestine), which is available in fast and slow absorbing types. Chromic gut is treated with chromium salts to slow absorption.

Natural Nonabsorbable

Natural nonabsorbable sutures include surgical silk, surgical stainless steel (for suturing bone, e.g., a sternotomy), and cotton. Note: Surgical steel wire is specified according to the Brown and Sharpe wire gauge, not the Stubs needle gauge.

Synthetic Absorbable

Examples of synthetic absorbable sutures include Polygalactin 910 (Vicryl™), poliglecaprone 25 (Monocryl™), polydioxanone (PDS II™), and polytrimethylene carbonate (Maxon™).
Synthetic Nonabsorbable

Synthetics nonabsorbable sutures include Nylon (Ethilon™, Dermilaon™, monofilament Nurlon™, Surgilon™ braided), polybutester (Novofil™), polyester fiber (Mersilene™/Dacron [uncoated] and Ethibond™/Ti-cron™ [coated]), and polypropylene (Prolene™).*

Trocars and Dilators

Trocars

Trocars are usually larger diameter devices used to make a surgical entry into the body. Trocars are common features of laparoscopic and arthroscopic surgical ports.

Blunt Dilators

A blunt dilator is used to dissect rather than cut tissue (see Figures 3.6–3.9). A blunt dilator is used to minimize a tissue defect from cutting, or to protect sensitive tissues distal to the axis of penetration (e.g., bowel in laparoscopy or articular cartilage in arthroscopy).

Plastic Sharps and Trocars for Disposables

Plastic sharps, as well as dilators, are commonly used in single-use disposable medical devices. When properly designed, plastic parts have sufficient penetration acuity. Plastic sharps are common in disposable intravenous (IV) bag spikes. There are

FIGURE 3.6 Metal trocar and blunt dilator.

* For detailed engineering information on sutures, see C. C. Chu, J. A. von Fraunhofer, and H. Greisler, Wound Closure Biomaterials and Devices (Boca Raton, FL: CRC Press, 1997).
FIGURE 3.7 Assorted plastic sharp and blunt devices.

FIGURE 3.8 Plastic dilator and trocar handles showing coring out of thick sections.

FIGURE 3.9 Needle terminology. (Illustration courtesy of Connecticut Hypodermic, Yalesville, CT.)
numerous designs for laparoscopic trocars that incorporate a combination of plastic and metal components.

An important design consideration in plastics is to minimize thick sections of material. Excessively thick sections make for long molding cycle times as well as potential voids and molded in stress.

**GLOSSARY OF NEEDLES AND RELATED TERMS**

**Abrams’ needle:** A biopsy needle designed to reduce the danger of introducing air into tissues; used in pleural biopsy.

**Acuity:** The sharpness of a surgical needle.5

**Agar cutting needle:** A needle with a sharpened punch end and an obturator to pick up and transfer a sample of agar media.

**Aneurysm needle:** A needle with a handle, used in ligating blood vessels.

**Angle of rotation:** The amount of rotation performed on secondary grinds (lancets) of a cannula. This is an important variable for needle-point sharpness.

**Anneal:** A heat-treating process is performed on metal to make it more malleable. This can aid many small-diameter stainless steel tube components that are bent, flared, or swaged to prevent cracking or splitting.

**Anticoring heel blast:** The heel of a bevel is blasted with media to dull it in order to reduce coring. It is the heel of a needle that tends to produce coring. (See Figure 3.8 for location of needle heel.)

**Aspirating needle:** A long, hollow needle for removing fluid from a cavity.

**ASTM A 96796:** Chemical passivation standard for treating stainless steel parts. Replaces QQP-35C.

**Back bevels:** Bevels that are ground on the side of a flat bevel. This provides a greater cutting edge on a short-bevel needle.

**Bevel:** Ground surface of a cannula or needle point. There are many styles, including but not limited to A-bevel, B-bevel, C-bevel, bias, Chiba, Crawford, deflected tip, Francine, Hustead, Huber, trocar, and Tuohy.

**Bevel length:** Length measured from tip of needle point to farthest distance of heel.

**Bias:** Angle grind.

**Blunt end:** Tube with square-cut (90-degree) end.

**Brockenbrough needle:** A curved steel transseptal needle within a Brockenbrough transseptal catheter; used to puncture the interatrial septum.

**Burr:** Deflection of the point. Usually considered unacceptable when perceptible to feel or greater than 0.001.

**Cannula:** A hollow tube meant to be inserted into a body cavity, sometimes with the assistance of an inner sharp trocar or blunt obturator.

**Cataract needle:** A needle used in removing a cataract.

**Chiba needle:** A common type of thin, flexible biopsy needle with a small-diameter needle and a stylet in the needle lumen.

**Cope’s needle:** A blunt-ended hook-like needle with a concealed cutting edge and snare, used in biopsy of the pleura, pericardium, peritoneum, and synovium.
Deschamps’ needle: A needle with the eye near the point, and a long handle attached; used in ligating deep-seated arteries.

Discission needle: A special form of cataract needle.

Echotip: Creates an enhanced visualization of the needle tip when used with ultrasonic imaging equipment. This is where the tip is roughened or knurled or coated with an acoustic reflective material to increase echogenicity.

Emulsifying needle: A small tube with luer fittings at each end for mixing a liquid and an emulsifying agent by pushing the liquids through the tubing into opposing syringes. A simple type of static mixer.

Flared end: End of tube is spread out, increasing the diameter. Typically, flare diameter can be a maximum of 1.3 times the tube diameter.

Free length: On a needle assembly, free length is the length from the end of the part to the point at which it protrudes from the hub.

Gauge: Stub gauge number referring to hypodermic tube size. For hypodermic tubing, the gauge number increases as the tube diameter gets smaller.


Grit blast: Refers to roughened surface added to components by means of pressure blasting with media. This may provide a better bonding surface for hypodermic needles or tubing or wire components.

Hagedorn’s needles: Surgical needles that are flat from side to side and have a straight cutting edge near the point and a large eye.

Hasson cannula: A cannula made for laparoscopy with a blunt dilating obturator and an anchoring balloon at the distal end.

Hasson trocar: A blunt trocar inserted into the peritoneal cavity after a celiotomy. Used for insufflation and introduction of a laparoscope.

Hook burr: Burr on needle point that exceeds 0.002 inch.

Hub: Fitting at the end of a needle that can connect to a syringe or other component.

ID: Inside diameter of tubing, usually measured with pin gauges to determine proper size.

ISO 9626: International standard for stainless steel needle tubing for the manufacture of medical devices.

Knife needle: A slender knife with a needle like point, used in discission of a cataract and other ophthalmic operations, as in goniotomy and goniopuncture.

Lancets: These are the two secondary bevels on a triple-ground point. Other common terms for lancets are side grinds and diamond points.

Ligature needle: A slender steel needle with a long handle and an eye in its curved end, used for passing a ligature underneath an artery.

Luer: Male or female taper on the end of hub or syringe to connect a needle to a syringe or other Luer fitting. Hubs can be Luer Slip or Luer Lock, conforming to ISO 594-2.

Eponym for Otto Luer, who, in the 1880s, in Germany came up with the idea of a 6 percent taper as a way of putting a stopper in a bottle, keeping it there, and then getting it out again. Many years later, Luer’s taper was used
by hospital equipment manufacturers to ensure that one piece of IV set tubing would fit into another.*

In 1925 Fairleigh S. Dickinson, cofounder of Becton-Dickinson, patented what became known as the Luer-Lok™ fitting, which added to the Luer’s tapered fluid fitting a locking sleeve by incorporating a lead screw that prevented a hypodermic syringe from slipping off of a hypodermic syringe.† This made a hypodermic safer to use when dispensing viscous fluids, which tended to force the needle hub off of the luer slip fit. The luer lock fitting described in Dickinson’s 1930 patent‡ is virtually identical to locking luer fittings used in the 21st century.

After plastic medical disposable devices were introduced in the 1950s, the Luer-Lok fitting and variations of it were incorporated into a wide range of plastic medical fluid fittings.

**Lumen:** This is the open space inside a tube.

**Magnetic permeability:** The property of stainless steel tubing that determines its relative influence in a magnetic field. Work hardening of 300 series stainless can affect the magnetic permeability.

**Malleable:** Easily bendable without breaking or cracking. Small-diameter stainless steel tubing can be drawn to less-than-full-hard conditions to make it more malleable. Another method is to have the hypodermic tube size parts bright annealed through heat treating.

**Menghini needle:** A needle that does not require rotation to cut loose the tissue specimen in a biopsy of the liver. This represented a significant advance in the previously slow and hazardous methods of liver biopsy. “Menghini introduced modern liver biopsy in 1958. He used a new, very thin suction needle. His original article was entitled ‘One-Second Needle Biopsy of the Liver’ in the journal Gastroenterology.”§

**Obturator:** A blunt rod that fills the inner lumen of a cannula. A removable plug of a tubular instrument. From Latin obturo, “to close up.”

**Overall length (OAL):** Entire length measured from one end to opposite end.

**Passivate:** To treat stainless steel with acid to prevent corrosion per ASTM A 96796.

**Pencil point:** Tubing is swaged to conical point.

**Pitkin bevel:** A 45-degree bevel without a secondary lancet bevel.

**Proximal end:** Hub end of a needle; the end closest to you.

**Quincke bevel:** A type of needle grind named for Heinrich Irenaeus Quincke (1842–1922), a German, who pioneered the lumbar puncture technique for aspirating cerebral spinal fluid (CSF) to diagnose neurological disorders. A regular Quincke bevel is 22 degrees and a short Quincke bevel is 30 degrees.

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‡ U.S. patents 1,742,497 and 1,793,068.
Reverdin’s needle: A surgical needle having an eye that can be opened and closed by means of a slide.

Seldinger needle: A needle with a blunt, tapered external cannula with a sharp obturator; used for the initial percutaneous insertion characteristic of the Seldinger technique for arterial or venous access. The Seldinger technique is the common method for placing a guidewire into a vessel (e.g., into the femoral artery for cardiovascular access), to allow the placement of catheters over the guidewire. Named for Sven-Ivar Seldinger (1921–1999), radiologist, born in Mora, Sweden. Dr. Seldinger published the description of a percutaneous-entry technique in the journal Acta Radiologica.∗

Side port: Opening on the side of a tube. It can be a slot or hole.

Silverman needle: An instrument for taking tissue specimens, consisting of an outer cannula, an obturator, and an inner split needle with longitudinal grooves in which the tissue is retained when the needle and cannula are withdrawn.

Stop needle: A needle with a shoulder that prevents it from being inserted beyond a certain distance.

Stylet: A rod that fills the inner lumen of a hypodermic needle or trocar and is ground to match the sharp end of the needle or trocar.

Swaged needle: One permanently attached to the suture material. Curved needles for sUTuring tissue normally have the suture swaged to the proximal end of the needle.

Swaging: Forming process to reduce tube outside diameter (OD) and shape to die configuration. Also a method to crimp together.

Transseptal needle: A needle used to puncture the interatrial septum in transseptal catheterization.

Trephine: A saw-type end on a needle or cylindrical tube that allows cutting of tissue as the needle or cannula is rotated, similar to a hole saw. Often used to cut a disc-shaped piece of bone or other firm tissue.

Triple grind: Typical three-sided grind of hypodermic needle.

Trocar: A cannula with a three-pointed obturator stylet. Sometimes refers to the sharp obturator alone. From French trois (three) and carré (the edge of a sword).

Trocar point: Three-sided point ground on stylet. Each grind is approximately 120 degrees apart, usually to the center of the diameter.

Tuohy needle: One in which the opening at the end is angled so that a catheter exits at an angle. The end of the Tuohy needle provides controlled penetration during the administering of spinal anesthesia and placement of an epidural spinal catheter. Named after Edward B. Tuohy, an American anesthesiologist. Sometimes called the Huber needle, as it was designed jointly by Tuohy and Ralph Huber†. A pioneering development that made continuous epidural anesthesia in obstetrics possible.

Veress needle: Named for Janos Veress, a German doctor. A spring-loaded needle originally used to drain ascites and evacuate fluid and air from the chest. Was later

adapted to use in laparoscopy. A hollow needle consisting of a sharp trocar with a slanted end surrounding an inner cylinder with a blunt end. After the trocar is introduced into a body cavity, the blunt cylinder is advanced outward so that internal organs are not injured by the sharp edge. Used for insufflation of a body cavity, such as for pneumoperitoneum in minimally invasive surgery.

**RESOURCES**

**REFERENCE: PHLEBOTOMY**


**VENDORS: HYPODERMIC TUBES, NEEDLES, AND SHARPS**

Avid Medical
9000 Westmont Drive
Stonehouse Commerce Park
Toano, VA 23168
Toll Free: 800-886-0584
Fax: 757-566-8707

BG Sulzle
1 Needle Lane
N. Syracuse, NY 13212
Phone: 315-454-3221
Largest independent manufacturer of drilled end-suture needles.

Connecticut Hypodermics
519 Main Street
Yalesville, CT 06492
Phone: 203-265-4881
Fax: 203-284-1520

Disposable Instrument Company
P.O. Box 14248
Shawnee Mission, KS 66285-4248
Phone: 913-492-6492
Fax: 913-888-1762

Eagle Stainless
10 Discovery Way
Franklin, MA 02038
Toll Free: 800-528-8650
Fax: 800-520-1954

* Phlebotomy is the art of drawing blood with a needle.
Electron Microscopy Services
P.O. Box 550
1560 Industry Road
Hatfield, PA 19440
Phone: 215-412-8400
Fax: 215-412-8450
EMS supplies, microminiature needles, and sharps.

K-Tube
13400 Kirkham Way
Poway, CA 92064
Phone: 858-513-9229
Fax: 800-705-8823

Medical Sterile Products
P.O. Box 338
Rincon, PR 00743
Phone: 800-292-2889
Fax: 787-823-8665
Manufactures sharps of all kinds.

Microgroup
7 Industrial Park Road
Medway, MA 02053
Phone: 800-255-8823
Fax: 508-533-5691

Point Technologies
6859 N. Foothills Highway
Boulder, CO 80302
Phone: 303-415-9865
Fax: 303-415-9866
Point Technologies provides electrochemical sharpening of microwires.

Popper and Sons
300 Denton Avenue
New Hyde Park, NY 11040
Phone: 516-248-0300
Fax: 516-747-1188

Vita Needle Company
919 Great Plain Avenue
Needham, MA 02492
Phone: 909-699-8790
Fax: 909-699-7490
Specialize in small minimum lot manufacturing.
VENDOR: SHARPS DISPOSAL (MAIL ORDER)

GRP & Associates, Inc.
P.O. Box 94
Clear Lake, IA 50428
Phone: 888-346-6037

ACKNOWLEDGMENTS

The assistance of Bob Lamson of Microgroup, Zev Asch of Popper and Sons, Connecticut Hypodermics, and BG Sulzle, Inc., is gratefully acknowledged.

ENDNOTES

1. “The gauge system for sizing medical catheters and equipment is used widely around the world. Yet both its origins and its interpretation, in terms of conventional measurements, have long been obscure. The gauge, formally known as the Stubs Iron Wire Gauge, was developed in early 19th century England. Developed initially for use in wire manufacture, each gauge size arbitrarily correlates to multiples of .001 inches. This sizing system was the first wire gauge recognized as a standard by any country (Great Britain, 1884). It was first used to measure needle sizes in the early 20th century. Today it is used in medicine to measure not only needles, but also catheters and suture wires. However, owing to the potential confusion inherent in using a gauge system, the iron wire gauge is rarely used in manufacture of nonmedical equipment.” K. V. Iserson, “The Origins of the Gauge System for Medical Equipment,” Journal of Emergency Medicine 5 (1987): 45–48. See also J. S. Roll, “The Story of the Gauge,” Anaesthesia 54 (1999): 575–581.

2. For further reference, see http://www.sizes.com/materials/wire.htm. It is interesting to note that the Morse drill bit gauge system used today was copied from the Lancashire wire gauge system (yet another system), as this is the wire the Morse company apparently imported from England to manufacture its twist drills.

3. “Joseph-Frederic-Benoit Charriere, a 19th century Parisian maker of surgical instruments, has by virtue of his ingenuity and advanced thinking, continued to have his presence felt in medicine throughout the 20th century. His most significant accomplishment was the development of a uniform, standard gauge specifically designed for use in medical equipment such as catheters and probes. Unlike the gauge system adopted by the British for measurement of needles and intravenous catheters, Charriere’s system has uniform increments between gauge sizes (one-third of a millimeter), is easily calculated in terms of its metric equivalent, and has no arbitrary upper end point. Today, in the United States, this system is commonly referred to as French (Fr) sizing. In addition to the development of the French gauge, Charriere made significant advances in ether administration, urologic, and other surgical instruments, and the development of the modern syringe.” K. V. Iserson, “J.-F.-B. Charriere: The Man behind the French Scale,” Journal of Emergency Medicine 5 (1987): 545–548.

5. “The acuity (sharpness) of surgical needle points was assessed by measuring the force required for repeat needle penetrations through a medium-gauge latex sheet glued to a perforated Plexiglas frame. The data on the variation in the applied force with repeat penetrations showed that needles obeyed the general relation: \( P = A + B \cdot n \); where \( P \) is the applied penetration force in grams, \( n \) is the number of penetrations, and \( A \) and \( B \) are constants. Constant \( A \) characterized the needle-point acuity and \( B \) the maintenance of acuity. This relationship indicated both needle acuity and acuity maintenance with repeated passes through a reproducible target material. Determining the microhardness of needles provided data on their strength, which helped to account for differences in the acuity of apparently similar needles. The tensile strength of the union between suture and needle was determined to evaluate the security of suture attachment.” J. A. von Fraunhofer, R. J. Storey, and B. J. Masterson, “Characterization of Surgical Needles,” *Biomaterials* 9 (1988): 281–284. See also T. B. Frick, et al., “Resistance Forces Acting on Suture Needles,” *Journal of Biomechanics* 34 (2001): 1335–1340.