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Tropello

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(54) **COAPTATION ULTRASOUND DEVICES AND METHODS OF USE**

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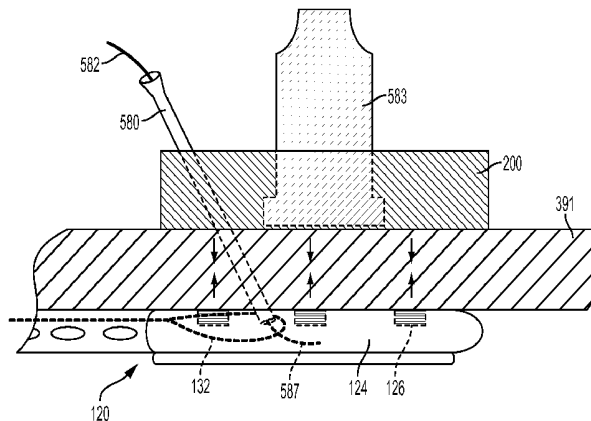
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Primary Examiner — Peter Luong

(57) **ABSTRACT**

Disclosed is a system and method for the placement of
elongate medical members within a patient's body using
coaptive ultrasound that combines magnetic guidance with
ultrasound visualization of the medical member in the
patient's body. A coaptive ultrasound probe adaptor mag-
netically attracts an elongate medical member within the
patient with sufficient force so as to allow the operator to
manually guide the member to its intended location. The
adaptor mates with an ultrasound probe to provide the
medical operator ultrasound feedback of the position of the
member, thus allowing internal placement without the need
for more specialized medical equipment.

29 Claims, 10 Drawing Sheets



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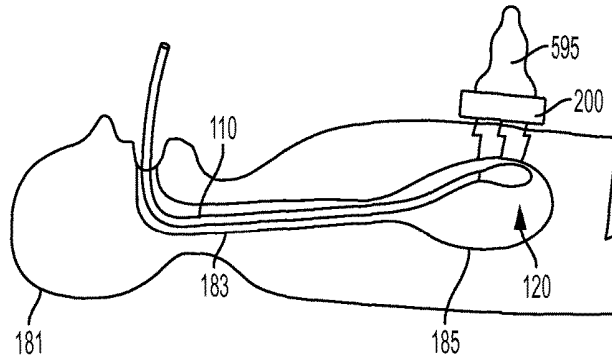


FIG. 1

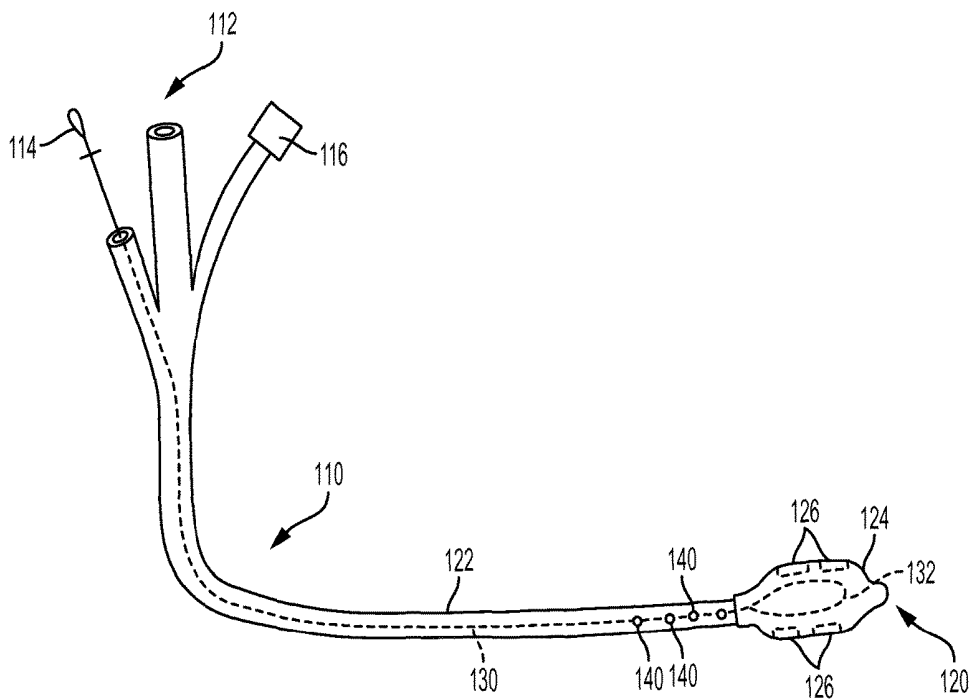


FIG. 2

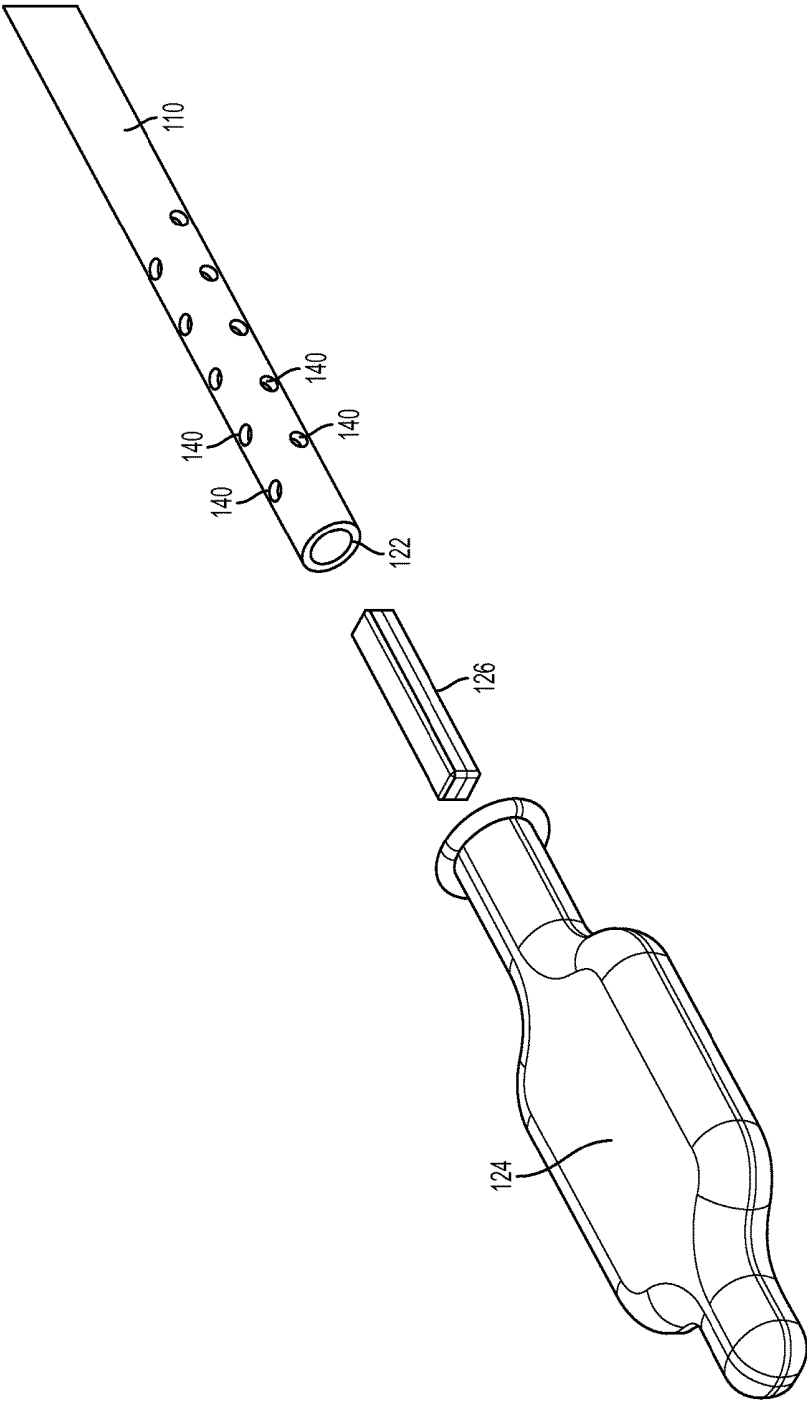


FIG. 3

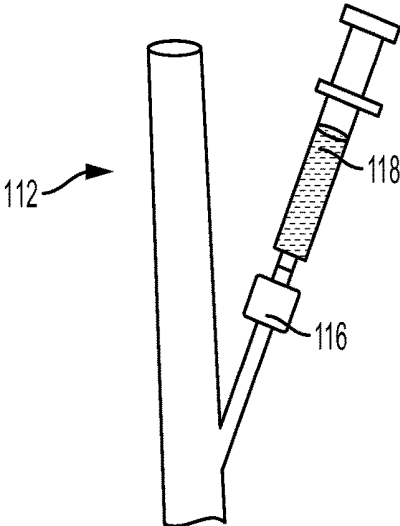


FIG. 4

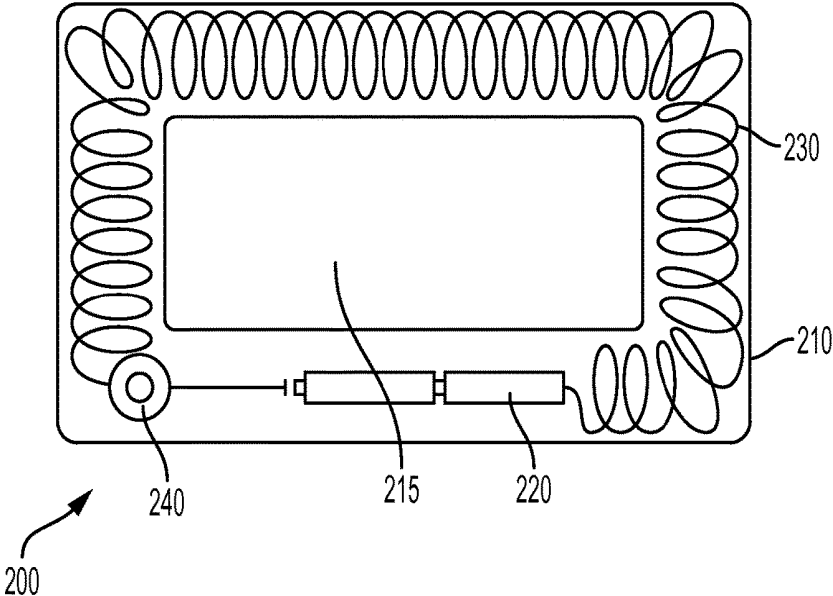


FIG. 5a

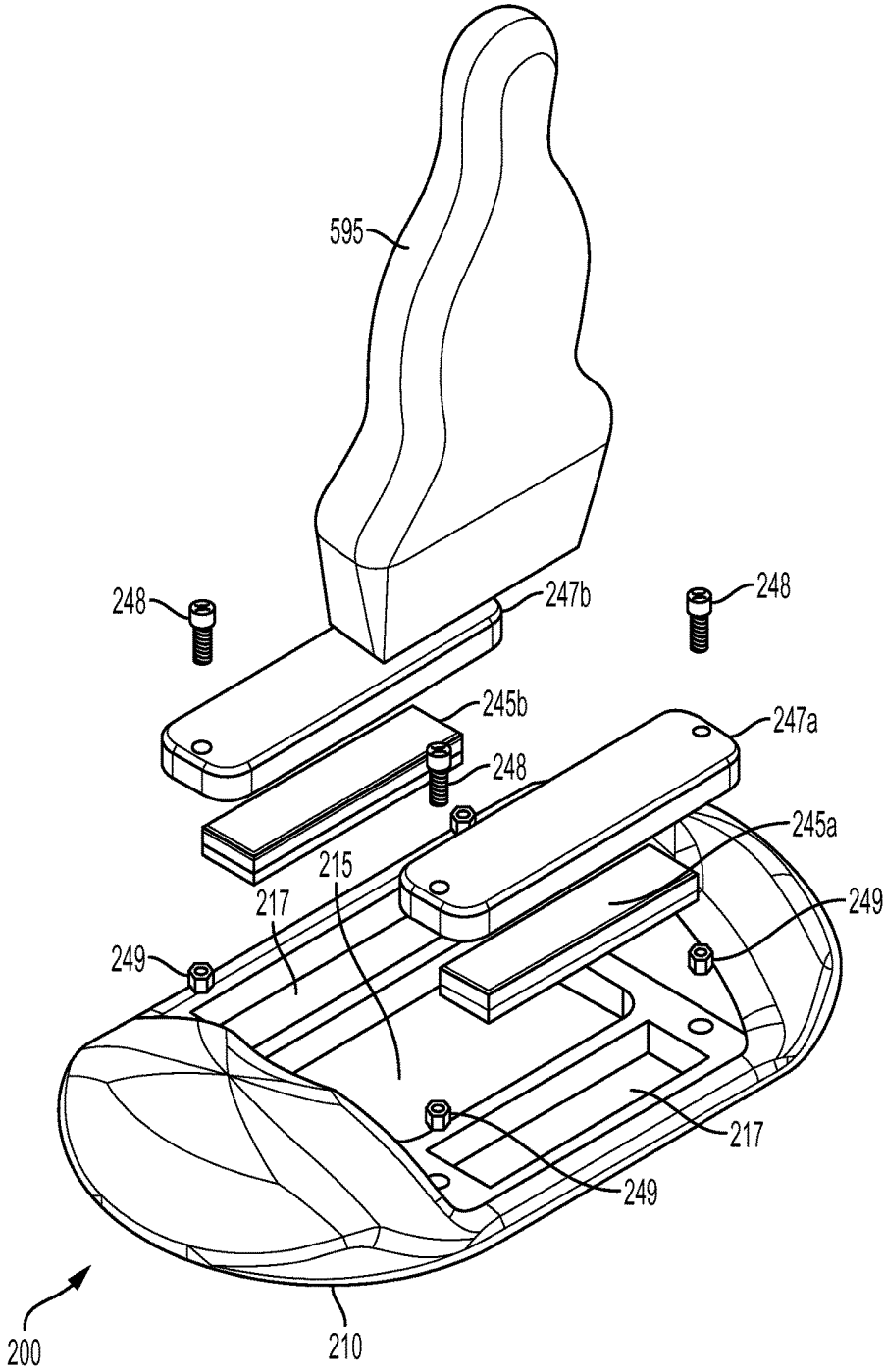


FIG. 5b

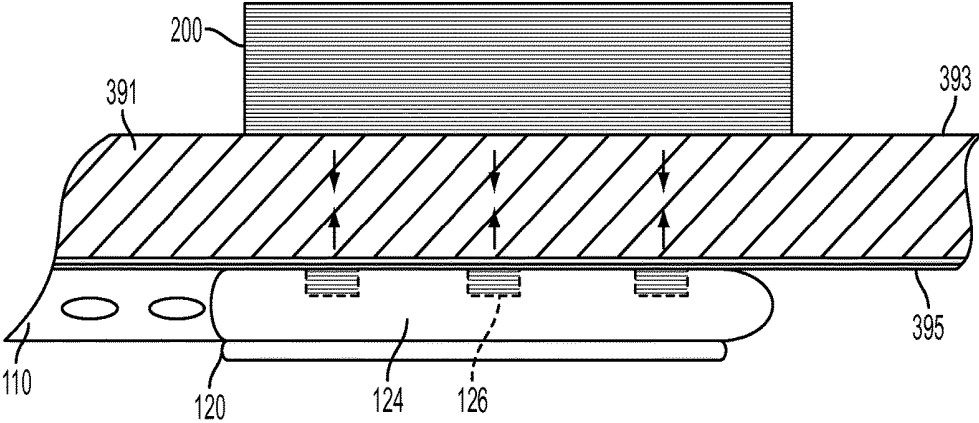


FIG. 6

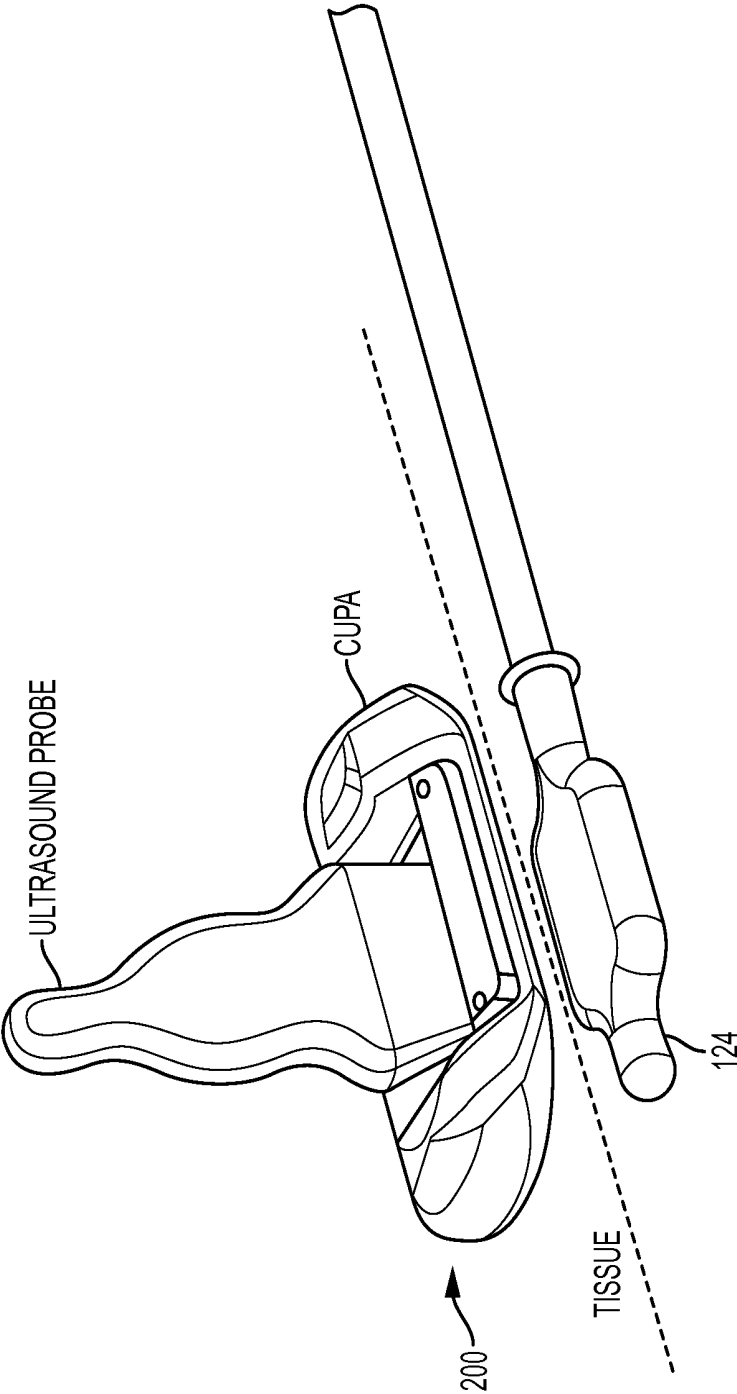


FIG. 7

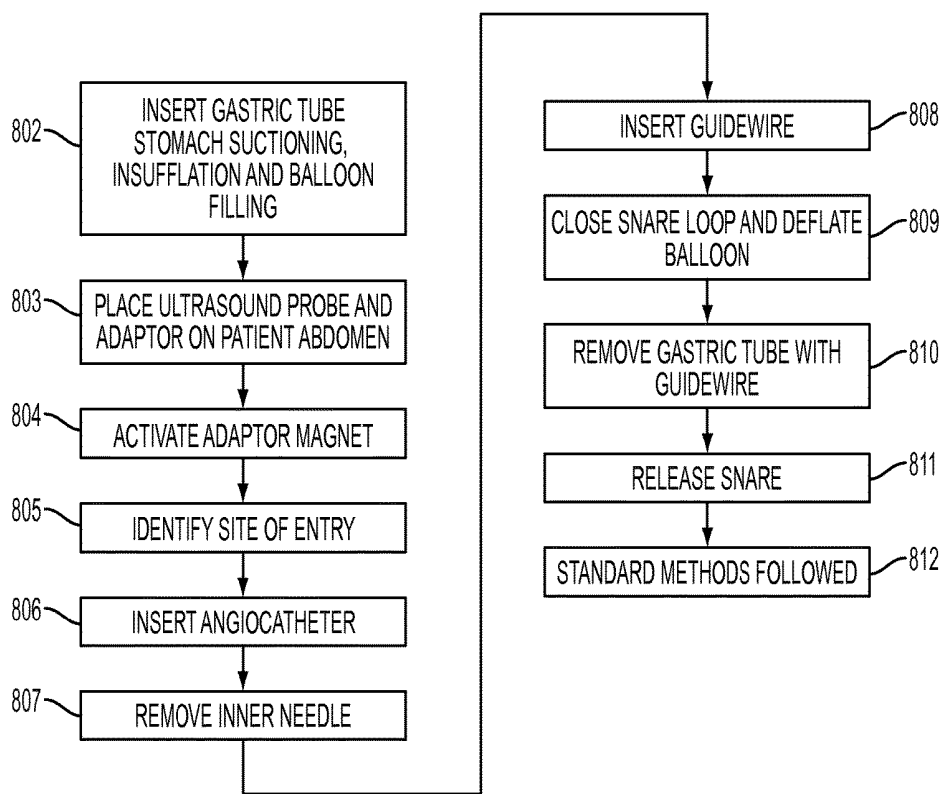


FIG. 8

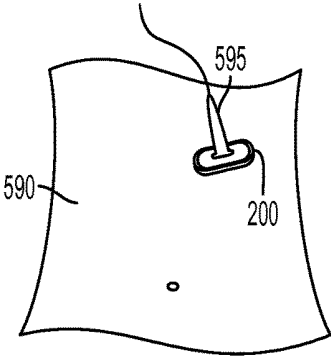


FIG. 9

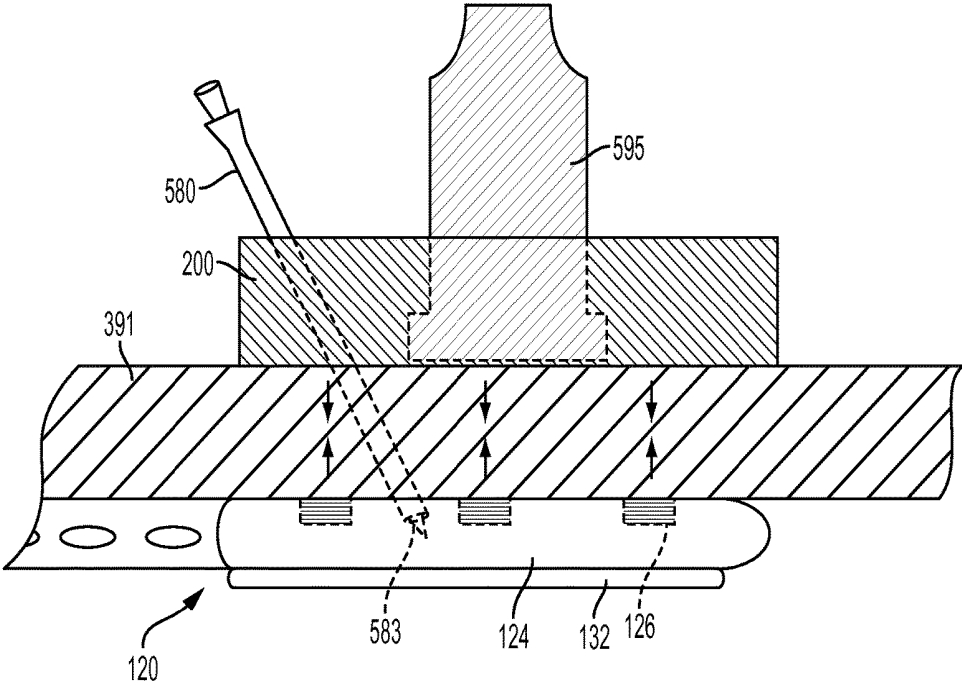


FIG. 10

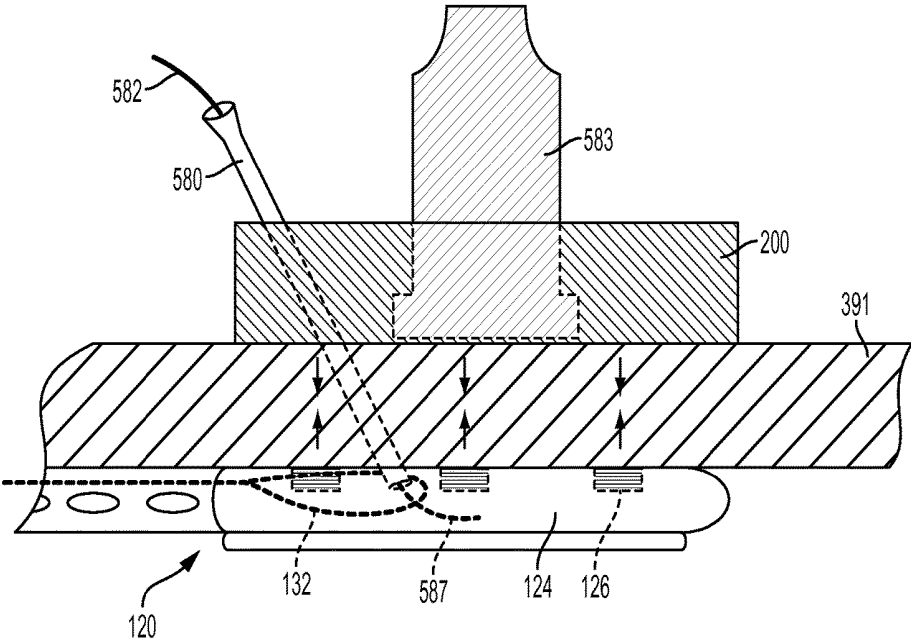


FIG. 11

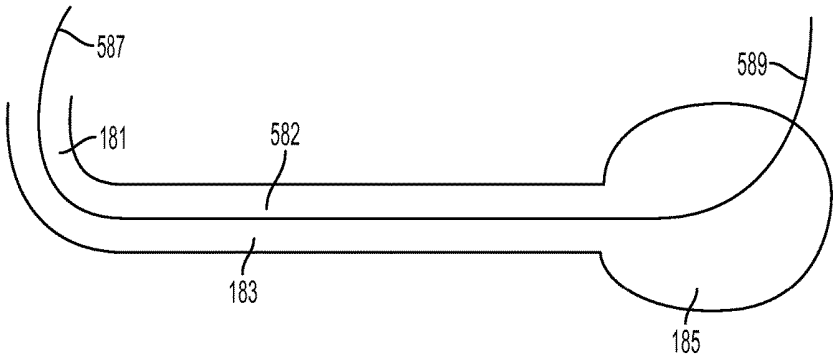


FIG. 12

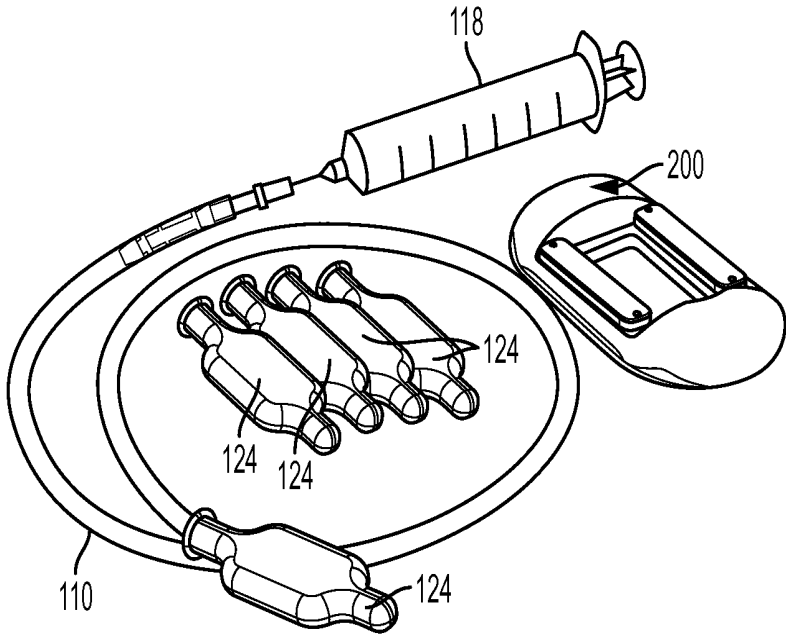


FIG. 13

COAPTATION ULTRASOUND DEVICES AND METHODS OF USE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. § 371 to, and is a U.S. national phase entry of, International Application No. PCT/US2014/034950, entitled "Coaptation Ultrasound Devices and Methods of Use," filed Apr. 22, 2014, which claims priority to and the benefit of U.S. Provisional Patent Application Ser. No. 61/814,516, entitled "Coaptation Ultrasound Devices and Methods of Use," filed with the United States Patent and Trademark Office on Apr. 22, 2013, by the inventor herein, the disclosure of each of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates generally to placement of medical devices within a body in the medical field, and more particularly to methods and devices for ultrasound-guided placement of medical devices, such as catheters, conduits, carriers, electrodes, and the like into a patient's body.

BACKGROUND OF THE PRIOR ART

A wide variety of medical procedures require placement of medical devices at various locations within a patient's body. For instance, certain procedures may require the placement of electrodes within a patient's spine, or attachment of electrodes to heart tissue, or the like. In other procedures, medical staff may wish to place temperature probes or heating wires at various locations within patient's body. Further, for cancer treatment, medical staff may wish to place radioactive seeds or deliver therapeutic medications deep within a patient's body, including directly into internal organs. In still other procedures, medical staff may wish to place catheters or other fluid or material-carrying conduits within the patient's body for delivery of medications or other materials, for carrying forceps, biopsy instruments or the like into the patient's body, for providing suctioning to various parts of a patient's body, and many other procedures involving the placement of medical devices within the patient's body. Procedures for placing such medical devices vary widely from application to application, but all carry the common aspect of presenting challenge to the medical staff in manipulating such medical devices within the patient's body to route them to their intended location and position them for their intended use at that location.

More particularly, often times medical procedures require manipulation of a catheter or other conduit through portions of the patient's body that are not easily accessible, and thus make maneuvering of the conduit to its intended location quite challenging. For instance, it may be medically necessary to place conduits within internal body cavities to provide for the drainage of unwanted fluid, to provide for the infusion of medications into internal organs or elsewhere in the body, to provide for direct nutritional supplementation to patients unable to orally consume adequate nutrition, and the like. The procedures for guiding such conduits to their intended locations in a patient's body can be difficult to perform and can risk serious injury to the patient if not performed properly.

One such procedure that presents significant challenges is the placement of gastrostomy tubes for patients requiring direct nutritional supplementation into the stomach. Enteral

feeding has been recommended when a patient has a functioning gut but is unable to eat for seven to fourteen days. When enteral feeding is anticipated to be required for longer than 30 days, a gastrostomy tube is preferred over a nasogastric tube. The placement of gastrostomy tubes has become a frequently required procedure, with more than 215,000 being placed annually in the United States. The vast majority of such procedures are performed by consultants, such as gastroenterologists and interventional radiologists, as opposed to an emergency room doctor, an intensivist, or patient's primary physician. This is because those specialized consultant physicians have access to and have been trained on the expensive equipment that one must use to safely enter (i.e., cannulate) the stomach (i.e., gastrostomy). This expensive equipment includes endoscopes, fluoroscopes, and computed tomography (CT) scanners, all of which require specialized training and skill to operate properly.

The most common method for initial gastrostomy tube insertion is Percutaneous Endoscopic Gastrostomy ("PEG"), involving placing of a PEG tube into the patient's stomach. When performing a typical PEG process, a patient is placed in the supine position. A nasal or oral gastric tube is then introduced into the patient's stomach. Gastric fluid is removed using suction, such as through fenestrations at the distal end of the nasal or oral gastric tube. The stomach is then insufflated by way of the gastric tube or an endoscope. In one method, the endoscope has a light at the distal end. When illuminated, the practitioner is supposed to identify a suitable puncture site that is free from interposed organs and large vessels by noting where the light from the endoscope shines through the abdominal skin of the patient. An incision is then made at the identified target site, and a sheathed needle is then entered into the insufflated stomach. A guide wire is then introduced through the abdominal sheath and into the stomach. A snare or forceps located at the distal end of the endoscope is manipulated to capture the end of the guide wire. The endoscope is then extracted, pulling the guide wire along and ultimately causing the guide wire to exit through the mouth or nose. Applicant is aware of two preferred methods to complete the gastrostomy after the guide wire has been routed from the outside of the patient's abdomen, into their stomach, up their esophagus and out through their mouth or nose: the Ponsky-Gauderer (pull-(on) string) method (the "PG method"), and the Sacks-Vine (push-over-wire) method (the "SV method").

If the PG method is selected, the gastrostomy tube is tied to the end of the guide wire that has exited through the patient's nose or mouth. The abdominal end of the guide wire is then pulled until the gastrostomy tube extends out from the hole in the abdomen, with the proximal end of the gastrostomy tube (having an enlarged end, or bumper, therein to prevent it from passing through the stomach wall and out of the patient's abdomen) remaining within and providing access to the interior of the patient's stomach. If the SV method is selected, the gastrostomy tube is placed over the guide wire and is pushed toward the stomach from the patient's mouth until it extends out from the abdominal hole. Again, the gastrostomy tube has a bumper to prevent the tube from passing entirely through the abdominal hole and causing the proximal end to remain in the stomach.

Alternatively, percutaneous gastrostomy placement can be performed using gastropexy methods. Gastropexy wires are inserted into the stomach via the angiocatheter and used to tether the stomach. Standard gastropexy techniques are then used to place the gastrostomy tube over a guide wire inserted only within the stomach.

Even with skilled consultant physicians handling these procedures, complications can occur including tube misplacement, inadvertent injury to surrounding tissues during placement, infections, tube clogging, and tube dislodgement during use. When such complications occur outside of the hospital, patients will often come to a hospital emergency room for help. However, as the PEG procedures require specialized skill in handling, emergency medicine physicians are often unable to perform the necessary procedures, and must instead call upon such specialist consultants, which adds to the overall expense and delay in treating the patient's issue, or risk of further complication or injury if someone lacking sufficient specialized skill attempts to address the issue.

Accordingly, there is a need in the art for a device and method that will allow for placement of a medical device into a patient's body, such as the performance of percutaneous gastrostomies, at the bedside and that will no longer require the expertise and equipment of specialist medical personnel, such as a gastroenterologist or other specialist. It would be advantageous to provide a method and device that would reduce the difficulties associated with installing medical devices inside of a patient's body, including medical instrument carriers, medication carriers, electrodes, probes, catheters and other conduits, and that would thereby reduce the risks of injury associated with previously known methods and devices.

DESCRIPTION OF THE INVENTION

Disclosed herein is a system and method for placement of a catheter, conduit, or other elongate member within a patient's body that utilizes coaptive ultrasound that combines magnetic guidance with ultrasound visualization of the elongate member in the patient's body. Such system and method are suitable for use in therapeutic interventional and/or diagnostic procedures, and may be useful for placement and guiding of medical devices, including catheters or other conduits, in varied tissue planes and cavities in a patient's body, including by way of non-limiting example the thorax, abdomen, blood vessels, and pericardium, for diagnostic, therapeutic, and/or procedural purposes. For example, such system and method may be useful in the placement and manipulation of a catheter within a patient's stomach during a procedure for placement of a gastrostomy tube. Further, such system and method may be useful in the positioning and manipulation of a suction tube within a patient's body to remove unwanted fluid, such as by way of an initial surgical insertion of the suction tube in a region within the patient's body that has a low risk of complication or injury, and then fine manipulation of the suction tube in the intended location through magnetic guidance from outside of the patient's body. Similarly, such system and method may be useful for delivering medications through a conduit to targeted regions or organs within the patient's body, and for deploying probes, sensors, electrodes, and similarly configured devices within the patient's body. Still further, such system and method may be useful in obtaining tissue, fluid, and biopsy samples from within the patient's body, such as by magnetically guiding a forcep- or biopsy instrument-carrier to the intended site within the patient's body.

As used herein, all of such carriers, catheters, conduits, delivery devices, internal probes and sensors, electrodes, and the like that are intended for insertion into and movement or manipulation within a patient's body are referred to generally as "elongate medical members."

A coaptive ultrasound probe adaptor is provided that is configured to magnetically attract an elongate medical member, such as a catheter or the like, positioned within the patient with sufficient force so as to allow the medical operator to manually guide the catheter or other conduit or elongate medical member to its intended location. The adaptor is also configured to mate with an ultrasound probe, such that as the medical operator is remotely manipulating the catheter or other elongate medical member, they may likewise receive visual ultrasound feedback of the position of the catheter or other elongate medical member within the patient's body. By allowing visual confirmation through the use of readily-available ultrasound equipment, internal catheter, conduit, or other elongate medical member placement can be achieved without the need for expensive, specialized equipment, such as endoscopes, fluoroscopes, and CT scanners. Thus, the system and method disclosed herein will enable acute care physicians, such as emergency medicine physicians and critical care physicians (i.e., intensivists), or other healthcare providers trained in the art of ultrasound, to place such catheters, conduits, and other elongate medical members safely and reliably.

With regard to certain aspects of an embodiment of the invention, the system and method may be used for inserting gastrostomy tubes in a simple bedside procedure without requiring the use of specialized consultants or specialized equipment including endoscopes, fluoroscopes, and CT scanners. The system and method make use of more widely available medical devices that require less specialized training to use, such as ultrasounds, feeding tubes, guide wires, and dilators. By allowing a wider population of medical operators to perform such procedures, the system and method disclosed herein offer safer, more immediate and more cost-effective care. For example, unlike endoscopes, ultrasound ensures that an adequate window for percutaneous gastrostomy tube insertion is present by providing visual confirmation that no bowel, organs, or blood vessels obstruct the cannulation track between the skin surface and the stomach wall. Further, with this procedure, emergency medicine physicians may easily re-insert dislodged gastrostomy tubes and immediately discharge patients back to their residence instead of admitting them for traditional PEG placement to be performed by a specialist consultant, thus saving time and decreasing consultation costs, hospital admission costs, patients' stress, and the risk of nosocomial infection. Geriatricians and rehabilitation physicians may likewise use the system and method disclosed herein in nursing home and rehabilitation facilities. This practice could dramatically reduce overall costs by eliminating transportation costs and thus avoiding all hospital fees.

Still other applications of the disclosed system and method for magnetically attracting an internally positioned elongate medical member to an externally positioned, ultrasound-enabled adapter for coordinated movement and manipulation of the elongate medical member by the adapter will be apparent to those of ordinary skill in the art without departing from the spirit and scope of the invention.

With regard to further aspects of an embodiment of the invention, a kit embodying the system is provided that may also include feeding tubes, guide wires, and dilators.

BRIEF DESCRIPTION OF THE DRAWINGS

The numerous advantages of the present invention may be better understood by those skilled in the art by reference to the accompanying figures in which:

FIG. 1 is a schematic view of a gastric tube and ultrasound probe adaptor used for gastrostomy procedures in accordance with certain aspects of an exemplary embodiment of the invention.

FIG. 2 is a side view of the gastric tube of FIG. 1.

FIG. 3 is a close-up perspective exploded view of the distal end of the gastric tube of FIG. 1.

FIG. 4 is a close-up side view of the proximal end of the gastric tube of FIG. 1.

FIG. 5a is a schematic, cross-sectional top-down view of the ultrasound probe adaptor of FIG. 1.

FIG. 5b is a perspective exploded view of an ultrasound probe adaptor in accordance with certain aspects of an embodiment of the invention.

FIG. 6 is a side, cross-sectional view a patient's abdomen showing the positioning of an ultrasound probe adaptor in relation to the distal end of a gastric tube of FIG. 1.

FIG. 7 is a side perspective view of the positioning of an ultrasound probe adaptor in relation to the distal end of a gastric tube of FIG. 1 in accordance with certain aspects of an exemplary embodiment of the invention.

FIG. 8 is a flow diagram schematically representing an exemplary method of performing a gastrostomy in accordance with certain aspects of an embodiment of the invention.

FIG. 9 is a schematic view of the placement of an ultrasound probe on a patient's body.

FIG. 10 is a schematic view of the insertion of an angiocatheter into a patient's stomach in accordance with certain aspects of an embodiment of the invention.

FIG. 11 is a schematic view of the capture of a guide wire within a patient's stomach in accordance with certain aspects of an embodiment of the invention.

FIG. 12 is a schematic view of a guide wire placed within a patient's body in accordance with certain aspects of an embodiment of the invention.

FIG. 13 shows a kit for placing a conduit within a patient's body in accordance with certain aspects of an embodiment of the invention.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

The invention summarized above may be better understood by referring to the following description, claims, and accompanying drawings. This description of an embodiment, set out below to enable one to practice an implementation of the invention, is not intended to limit the preferred embodiment, but to serve as a particular example thereof. Those skilled in the art should appreciate that they may readily use the conception and specific embodiments disclosed as a basis for modifying or designing other methods and systems for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent assemblies do not depart from the spirit and scope of the invention in its broadest form.

FIG. 1 is a schematic view of a system in accordance with certain aspects of an exemplary embodiment of the invention. As shown in FIG. 1, a gastric tube 110 is inserted into a patient's stomach 185, entering the patient through the head 181 (either through the patient's mouth or nose) and down through the patient's esophagus 183, with the distal end (shown generally at 120) of gastric tube 110 ultimately being positioned within the patient's stomach. Also as shown in FIG. 1, an ultrasound probe adaptor 200, which is configured to receive an ultrasound probe 595, is position-

manually moved by a medical operator, along with ultrasound probe 595, to provide a visual image of the patient's abdomen using ultrasound methods well known to those of ordinary skill in the art.

Ultrasound probe adaptor 200 and the distal end of gastric tube 110 are configured to be magnetically attracted to each other. More particularly, both ultrasound probe adaptor 200 and the distal end of gastric tube 110 (or other elongate medical member, such as a catheter or conduit member as may be used throughout a patient's body and particularly other than in a patient's stomach) have magnetic members, as will be discussed in further detail below, that provide a sufficient attraction force between them so as to (i) cause the distal end of gastric tube 110 to come into contact with the internal tissue surface that is immediately adjacent the distal end of gastric tube 110 and closest to probe adaptor 200, and (ii) cause distal end of gastric tube 110 to move within the patient's body in response to movement of probe adaptor 200 and in a motion that corresponds to motion of probe adaptor 200 outside of the patient's body. While the particular magnetic members necessary to provide such magnetic attraction may vary, specific configurations of such magnetic members will be described by way of example in further detail below.

As shown in the detail view of FIG. 2 and in accordance with certain features of an exemplary embodiment, gastric tube 110 comprises a lumen 122 extending from proximal end 112 of gastric tube 110 to distal end 120 of gastric tube 110. Proximal end 112 of gastric tube 110 may be provided additional functional elements, including a snare release 114, which provides a mechanism allowing the practitioner to control a snare positioned at distal end 132. The practitioner may push or pull snare release 114 to open or close the snare 132. Further, a syringe port 116 may be provided at proximal end 112 of gastric tube 110, providing a passageway to inflate a balloon 124 at the distal end 120 of gastric tube 110. Further, in some embodiments of the invention, one or more ports (not shown) may be provided at proximal end 112 of gastric tube 110 to connect external suction or insufflation devices. Such suction and insufflation ports may connect to one or more lumens that extend along the length of gastric tube 110.

With continued reference to FIG. 2, distal end 120 of gastric tube 110 includes one or more balloons 124 that may be inflated by the practitioner, such as by injecting a fluid through syringe port 116 into balloon 124 via lumen 122. Inflation of the balloon 124 inside of the patient's stomach 185 will provide an echogenic space that may be observed by the practitioner when viewing an ultrasound image of the patient's stomach produced by ultrasound probe 595, thus allowing the practitioner to confirm that the distal end 120 of gastric tube 110 is in its intended location within the patient's body.

Those skilled in the art will recognize that while a balloon 124 is shown as providing an echogenic space that may be observed via ultrasound, other echogenic configurations that will provide an image through an ultrasound procedure may likewise be provided on an elongate medical member without departing from the spirit and scope of the invention.

In order to configure distal end 120 so as to be magnetically attracted to ultrasound probe adaptor 200, distal end 120 is also preferably configured with one or more magnets 126. For example, magnets 126 may be positioned within and fixedly attached to the interior walls of balloon 124. Alternatively or additionally, magnets 126 may be located along the shaft of distal end 120 of gastric tube 110, and may be positioned internally along the distal end 120 of gastric

tube **110**, or externally (such as by clipping, by adhesive attachment, or otherwise) along the distal end **120** of gastric tube **110** or on the outside of balloon **124**, without departing from the spirit and scope of the invention. Many different configurations of magnets **126** may be used in order to ensure proper alignment with and attraction to ultrasound adaptor **200**.

Still further, distal end **120** of gastric tube **110** may be provided one or more tube fenestrations **140** that communicate with suction and/or insufflation ports at proximal end **112** of gastric tube **110**, if such ports are provided. Likewise, snare **132** is located at distal end **120** of gastric tube **110**, which snare **132** communicates with a snare operator, such as snare release **114**, via snare line **130**.

FIG. 3 shows a close-up exploded view of distal end **120** of gastric tube **110** according to certain aspects of an exemplary embodiment of the invention. As shown in FIG. 3, gastric tube **110** may be a generally cylindrical tube, and fenestrations **140** may be provided at the end of gastric tube **110** and aligned in axially-extending rows around the circumference of the end of gastric tube **110**. Lumen **122** extends through gastric tube **110**. Likewise, a flexible, inflatable balloon, which may be formed in varying shapes and sizes, is affixed to the end of gastric tube **110** and is in fluid communication with lumen **122** so that it may be inflated from the proximal end of gastric tube **110** with an echogenic medium, contrast agent or therapeutic agent. One or more magnets **126**, such as by way of non-limiting example a neodymium block magnet having an approximate thickness of $\frac{1}{4}$ " and an approximate length of $1\frac{1}{2}$ ", is also situated in the distal end **120** of gastric tube **110**, and may be positioned within balloon **124**, within lumen **122**, or bridging a portion of both balloon **124** and lumen **122**. Further, magnet **126** may be rigidly affixed to balloon **124** and/or lumen **122**, or may alternatively be positioned therein without fixation, so long as magnet **126**'s position will cause balloon **124** to be magnetically drawn toward ultrasound probe adaptor **200** when the probe adaptor is placed against the patient's abdomen. In a most preferred configuration, magnets **126** are situated along opposite side edges of balloon **124** so as to allow them to align with magnets positioned on ultrasound adaptor **200**, as further detailed below. Snare **132** and snare line **130** are not shown in FIG. 3 for clarity, but those skilled in the art will recognize that such elements would be present and in a configuration as is well known in the art.

FIG. 4 provides a close-up view of syringe port **116** located at the proximal end of gastric tube **110**. In the illustrated embodiment, syringe port **116** is attached to a syringe **118**. Syringe **118** may be filled with any type of fluid that is capable of expanding balloon **124** with an echogenic medium, contrast agent or therapeutic agent. In preferred embodiments, syringe **118** is filled with a non-toxic fluid that will enhance ultrasound imaging, such as by way of non-limiting example, water or saline. Gases may also be used to inflate balloon **124**. While the illustrated embodiment shows syringe **118** being a removable element, in certain embodiments syringe **118** may be a permanent element, making the fluid transfer system between syringe **118** and balloon **124** a closed system.

Next, FIG. 5a shows a schematic, cross-sectional top-down view of a coaptive ultrasound probe adaptor **200** in accordance with certain aspects of an embodiment of the invention. Adaptor **200** may be formed in a variety of different shapes to receive existing or yet-to-be-developed ultrasound probes. As used herein, "ultrasound probe" is intended to refer to any hand-held device configured to

provide ultrasound imaging. Ultrasound probe adaptor **200** includes a magnetic source, and is physically configured so as to attach to an ultrasound probe **595**. In the embodiment shown in FIG. 5a, the magnetic source comprises an electromagnet having a power source **220**, a variable resistor dial **240**, and a coil **230**, all contained within an external housing **210**. Likewise, in order to attach to an ultrasound probe in the illustrated embodiment of FIG. 5a, housing **210** is provided an ultrasound probe receiver, such as a central cavity **215**, into which the scanning head of an ultrasound probe may be inserted. Alternatively, adaptor **200** may attach to an ultrasound probe **595** by clipping on to one or more edges of the probe, or in other ways as may be apparent to those of ordinary skill in the art. Likewise, while the illustrated embodiment of FIG. 5a depicts a single electromagnetic configuration, other magnetic configurations and types may be used, such as ferromagnets positioned within housing **210**, without departing from the spirit and scope of the invention. Likewise, variable resistor dial **240** or other adjustment devices may be used to increase or decrease the magnetic force of coil **230**, in static or alternating frequency patterns, or alternatively no adjustment device may be provided, again without departing from the spirit and scope of the invention.

FIG. 5b shows a close-up exploded view of a coaptive ultrasound probe adaptor **200**, along with an ultrasound probe **595**, according to certain aspects of a particularly preferred embodiment of the invention. As shown in FIG. 5b, ultrasound probe adaptor **200** includes base **210** having central cavity or opening **215** centrally located in the base **210** and extending through the entire thickness of base **210**, such that ultrasound probe **595** may be placed in opening **215** and in contact with a patient's skin on which ultrasound probe adaptor **200** is positioned. With regard to an aspect of a particularly preferred embodiment of the invention, opening **215** is sized having a width dimension that is less than the width of balloon **124** on gastric tube **110**, such that the sides of the balloon **124** extend past the long side edges of opening **215** when balloon **124** is magnetically attracted to ultrasound probe adaptor **200**. Further, magnet receiving slots **217** are positioned at opposing sides of opening **215**, and are each configured to removably receive a magnet **245a** and **245b** therein. Preferably, the magnets **245a** and **245b** are situated in opposite orientations from one another within their respective slots in ultrasound probe adaptor **200**. As a result, the practitioner is assured that ultrasound probe adaptor **200** will magnetically attract a balloon **124**, regardless of the orientation of the balloon **124** within the patient's body (i.e., regardless of which magnet pole is facing towards ultrasound probe adaptor **200**). In one embodiment, ultrasound probe adaptor **200** is configured to position magnets **245a** and **245b** a distance away from one another that approximately matches the distance between magnets **126** positioned in balloon **124** so as to provide for alignment of the long axes of balloon **124** and ultrasound probe adaptor **200** when the two are magnetically attracted to one another. A first cover plate **247a** may cover the magnet receiving slot **217** that receives magnet **245a**, and a second cover plate **247b** may cover the magnet receiving slot **217** that receives magnet **245b**. Each such cover plate **247a** and **247b** is preferably removably held over its designated receiving slot **217** with removable connectors, such as threaded bolts **248** that extend into nuts **249** that in turn are held within base **110**. As cover plates **247a** and **247b** are removable, and as magnets **245a** and **245b** are removable from slots **217**, magnets of varying strength may be positioned within slots **217** so as to vary the amount of magnetic attraction that will

be realized between ultrasound probe adaptor **200** and balloon **124**, which may be necessary for varying medical procedures and varying patient physiology (i.e., with larger tissue planes between the ultrasound probe adaptor **200** and balloon **124** requiring larger magnetic attraction and in some cases repulsion).

Next, FIG. **6** shows a cross-sectional view and FIG. **7** a perspective view of the coaptive ultrasound probe adaptor **200** interacting with balloon **124** through a tissue plane. More particularly, the distal end **120** of gastric tube **110** having balloon **124** is shown in FIG. **6** positioned inside of a patient's stomach, with ultrasound probe adaptor **200** positioned outside of the patient's body and in contact with the skin of the patient's abdomen. In the illustrated embodiment, ultrasound probe adaptor **200** is positioned directly against the patient's skin **393**, and the magnetic forces that attract balloon **124** to ultrasound probe adaptor **200** extend through the patient's skin **393**, through the subcutaneous tissue **391**, and through the stomach wall **395** (such tissue planes being hidden in FIG. **7** for clarity). Magnetic members in each of ultrasound probe adaptor **200** and balloon **124**, such as magnets **126**, cause balloon **124** to come into contact with stomach wall **395** and to push stomach wall **395** against the subcutaneous tissue **391** of the patient's abdomen (defined as coaptation), thus easing access to balloon **124** with a needle, cannula, or other device as described in greater detail below. Moreover, as best seen in FIG. **7**, the position of magnets **126** in balloon **124** and of magnets **245a** and **245b** in ultrasound probe adaptor **200** may cause the balloon **124** and adaptor **200** to align their long axes with one another, and allow coordinated movement between the two.

FIG. **8** is a flow diagram that depicts one method of performing a gastrostomy using the system of the present invention. Although steps are depicted in FIG. **8** as integral steps in a particular order for purposes of illustration, in other embodiments, one or more steps, or portions thereof, are performed in a different order, or overlapping in time, in series or in parallel, or are omitted, or one or more additional steps are added, or the method is changed in some combination of ways. Some of the steps are illustrated in FIGS. **9** through **12**. Moreover, while such method steps are specifically recited as corresponding to the performance of a gastrostomy, such gastrostomy process is referenced as exemplary only, and those of ordinary skill in the art will recognize that such method may be readily modified for many other procedures benefitting from remote, magnetic manipulation of an elongate medical member under ultrasound guidance using the general coaptive ultrasound methods shown in FIG. **8** without departing from the spirit and scope of the invention.

First, in step **802**, a gastric tube **110** configured as above is inserted through a patient's nose or mouth until the distal end **120** of the gastric tube **110** is positioned inside of the patient's stomach. Existing stomach contents are extracted, for example by applying suction through fenestrations **140** in the gastric tube **110**. Next, the stomach is insufflated, for example by using both the same or different channels and fenestrations in the gastric tube **110**. Syringe **118** is filled with non-toxic fluid. In steps **803** and **804**, ultrasound probe **595** and adaptor **200** are placed on the patient's abdomen **590** (as shown in FIG. **9**). If the ultrasound probe adaptor is provided an electromagnet, it is activated at this time. As a result of the magnetic attraction between the ultrasound probe adaptor **200** and the distal end of gastric tube **120**, the two components will align with one another along their long axes. Next, a suitable entry point is identified in step **805**.

Ultrasound probe **595** is used to ultrasonically image the patient's internal abdomen to detect any interposed organs or large vessels positioned between the ultrasound probe adaptor **200** and the balloon **124**.

In the event that ultrasound probe adaptor **200** is provided an electromagnet assembly, the strength of the magnet may be adjusted using the variable resistor dial **240**. Likewise, if ferromagnets are positioned in ultrasound probe adaptor **200**, the strength of the magnetic force generated by ultrasound probe adaptor **200** may be modified by simply changing the magnets **245a** and **245b** in adaptor **200**. In some cases, it may be necessary to reduce the magnetic attraction to allow for coordinated movement of the devices until a suitable entry point is identified. In other instances, it may be necessary to increase the magnetic attraction to account for excessive subcutaneous tissue. In any case, once a proper entry point is identified, the depth of the subcutaneous tissue may be measured to give the practitioner a reference point before making an incision.

Next, in step **806**, and as shown in FIG. **10**, an inner needle **583** and angiocatheter **580** are inserted into the patient's stomach through the abdomen, preferably through opening **215** in adaptor **200**. Inner needle **583** is then removed in step **807**, and in step **808** (and as shown in FIG. **11**), guide wire **582** is introduced through angiocatheter **580**. Once the distal end **587** of guide wire **582** is fed through snare **132**, snare **132** is closed and the balloon **124** is deflated in step **809**. Next, gastric tube **110** is removed from the patient in step **810**, and snare **132** is released in step **811** when the gastric tube is completely removed. FIG. **12** shows the final result of the method, in which guide wire **582** extends from the patient's stomach **185**, through the esophagus **183**, and out through the patient's head **181**. The proximal end **589** terminates outside of the patient's stomach. The distal end **587** terminates outside of the patient's nose or mouth. Once guide wire **582** is in place, the feeding tube may be inserted at step **812** using either the Ponsky-Gauderer method or the Sacks-Vine method, as described above.

In another embodiment, the devices of the present invention are used to introduce a percutaneous gastrostomy tube into a patient using gastropexy methods. In this method, steps **802** through **807** remain the same. However, after the inner needle is removed, one or more gastropexy anchors are inserted into the patient's stomach. Once the one or more anchors are fixated, standard gastrostomy methods follow using a guide wire placed only within the stomach.

FIG. **13** shows a kit for placing an elongate medical member, such as a conduit, within a patient's body in accordance with certain aspects of an embodiment of the invention. As shown in FIG. **13**, a kit preferably includes at least an ultrasound probe adaptor **200** configured as described above, a conduit **110**, a syringe **118** for connection to a proximal end of conduit **110**, a plurality of inflatable balloons **124** for connection to the distal end of conduit **110**, and at least one magnet **126** sized for insertion into each of balloons **124**. Preferably, more than one magnet **126** is provided, with the magnets preferably having differing magnetic strengths that a practitioner may select for a particular circumstance (e.g., for tissue planes of varying thickness). Also, while not shown in FIG. **13**, additional elements could be provided with such a kit, including items such as feeding tubes or other supply or fluid drainage conduits, guide wires, dilators, and the like, all without departing from the spirit and scope of the instant invention.

In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It

will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. Throughout this specification and the claims, unless the context requires otherwise, the word “comprise” and its variations, such as “comprises” and “comprising,” will be understood to imply the inclusion of a stated item, element or step or group of items, elements or steps but not the exclusion of any other item, element or step or group of items, elements or steps. Furthermore, the indefinite article “a” or “an” is meant to indicate one or more of the item, element or step modified by the article.

Having now fully set forth the preferred embodiments and certain modifications of the concepts underlying the present invention, various other embodiments as well as certain variations and modifications of the embodiments herein shown and described will obviously occur to those skilled in the art upon becoming familiar with said underlying concepts. It should be understood, therefore, that the invention may be practiced otherwise than as specifically set forth herein.

INDUSTRIAL APPLICABILITY

The present invention is applicable to devices and methods for placing medical devices into and manipulating such medical devices within patients, particularly through ultrasound-guided placement and manipulation. The devices can be made in industry and practiced in the medical device field.

What is claimed is:

1. A system for manipulating an elongate medical member within a patient's body, comprising:

an ultrasound probe adaptor having a first side and a second side, said ultrasound probe adaptor defining an opening extending from the first side to the second side and configured to receive a head of an ultrasound probe therein such that the ultrasound probe can contact a surface of the patient's body on which the second side of the ultrasound probe adaptor is disposed; and

an elongate medical member having a distal end and a proximal end, said distal end of said elongate medical member further comprising an echogenic head,

a snare including a snare line movably mounted within the elongate medical member, a snare closure coupled to a distal end of the snare line and disposed near said distal end of said elongate medical member, and a snare operator coupled to a proximal end of the snare line and disposed adjacent the proximal end of the elongate medical member;

wherein each of said ultrasound probe adaptor and said distal end of said elongate medical member are configured for magnetic attraction toward one another with a magnetic force allowing coordinated movement between said ultrasound probe adaptor and said echogenic head across opposite sides of at least one tissue surface on a patient's body.

2. The system of claim 1, said ultrasound probe adaptor further comprising at least a first magnetic member positioned adjacent said opening.

3. The system of claim 2, wherein said first magnetic member is removably positioned within said ultrasound probe adaptor.

4. The system of claim 2, said elongate medical member further comprising at least a second magnetic member positioned within said distal end of said elongate medical member.

5. The system of claim 4, wherein said second magnetic member is positioned inside of said echogenic head.

6. The system of claim 5, wherein said echogenic head further comprises a balloon.

7. The system of claim 6, wherein said first magnetic member is positioned on a first side of said opening in said ultrasound probe adaptor, and said second magnetic member is positioned on a first side of said balloon, said system further comprising:

a third magnetic member positioned on a second side of said opening in said ultrasound probe adaptor opposite said first magnetic member; and

a fourth magnetic member positioned on a second side of said balloon opposite said second magnetic member.

8. The system of claim 7, wherein said first and third magnetic members are spaced apart from one another a distance that is approximately equal to a distance by which said second and fourth magnetic members are spaced apart from one another.

9. The system of claim 4, wherein said first magnetic member and said second magnetic member have magnetic fields that are oriented so as to attract said distal end of said elongate medical member towards a bottom surface of said adaptor.

10. The system of claim 1, wherein said snare closure of said snare is positioned on an interior of said echogenic head.

11. The system of claim 1, wherein said ultrasound probe adaptor is configured to receive and engage with an external magnetic source such that the external magnetic source can contact the surface of the patient's body.

12. The system of claim 1, wherein the opening is configured to receive the head of the ultrasound probe adaptor such that the echogenic head can be visualized using the ultrasound probe.

13. An apparatus comprising:

a tube having a distal end and a proximal end and a lumen extending therethrough, the distal end configured to be disposed within the stomach of a patient via the esophagus of the patient;

a balloon coupled to the distal end of the tube and having a balloon wall defining an interior in fluidic communication with the lumen, the balloon being inflatable with a fluid delivered via the lumen into an inflated condition, the interior defining an echogenic volume in the inflated condition of the balloon, the balloon configured to receive into the interior through the balloon wall a distal end of a guidewire received via the skin and stomach wall of the patient; and

a magnet coupled to the distal end of the tube and disposed entirely within the balloon, the balloon inflatable such that the fluid delivered via the lumen is disposed between an outer surface of the magnet and an inner surface of the balloon wall, a position of the balloon and the distal end of the tube within the stomach of the patient controllable via magnetic attraction between the magnet and an external magnetic source disposed external to the patient.

14. The apparatus of claim 13, wherein the magnet is disposed in the lumen of the tube.

15. The apparatus of claim 13, wherein the magnet includes neodymium.

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16. The apparatus of claim 13, wherein the magnet has a length of about 1.5 inches.

17. The apparatus of claim 13, wherein the magnet has a thickness of about 0.25 inches.

18. The apparatus of claim 13, further comprising the external magnetic source configured to control the position of the balloon and the distal end of the tube by magnetic interaction with the magnet.

19. The apparatus of claim 13, further comprising an ultrasound probe adaptor having an opening configured to receive an ultrasound probe therein and to hold the ultrasound probe in contact with the skin of the patient, the external magnetic source being coupled to the ultrasound probe adaptor.

20. The apparatus of claim 13, further comprising:
 a snare line disposed in the lumen and extending there-through and having a proximal end disposed proximal to the proximal end of the tube and a distal end disposed in the balloon; and
 a snare coupled to the distal end of the snare line, disposed in the balloon, and configured to engage and retain the distal end of the guidewire received in the balloon interior so that the proximal end of the guidewire can be withdrawn from the patient by withdrawal of the proximal end of the tube from the patient via the patient's esophagus.

21. The apparatus of claim 13, further comprising:
 the external magnetic source configured to control the position of the balloon and the distal end of the tube by magnetic interaction with the magnet; and
 an ultrasound probe,
 wherein the external magnetic source and the ultrasound probe are fixed with respect to each other.

22. A system comprising:
 a tube having a distal end and a proximal end, the distal end configured to be disposed within the stomach of a patient via the patient's esophagus;
 at least one balloon configured to be coupled to the distal end of the tube, the at least one balloon defining an echogenic interior volume in an inflated condition;
 at least one magnet sized for insertion into the at least one balloon such that the at least one magnet can be disposed entirely within the at least one balloon, the echogenic interior volume defined between an outer surface of the at least one magnet and an inner surface of the at least one balloon in the inflated condition of the at least one balloon; and
 a syringe coupleable to the proximal end of the tube and configured to deliver fluid to the interior volume of the at least one balloon to inflate the at least one balloon to the inflated condition.

23. The system of claim 22, further comprising a guidewire configured to be inserted into the interior volume, a portion of the guidewire configured to be retained within the interior volume.

24. The system of claim 22, wherein the tube defines a lumen extending therethrough, the at least one magnet sized for insertion into the lumen.

25. The system of claim 22, further comprising:
 an ultrasound probe adaptor, said ultrasound probe adaptor having an opening extending therethrough configured to receive a head of an ultrasound probe therein, the ultrasound probe adaptor configured to engage an external magnetic source,
 the external magnetic source and the at least one magnet configured for magnetic attraction toward one another

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with a magnetic force allowing coordinated movement between the ultrasound probe adaptor and the at least one balloon across at least one tissue surface on a patient's body.

26. A system, comprising:

an external magnetic source having a skin-contacting surface, the external magnetic source configured to be moved along a skin of a patient while maintaining contact between the skin-contacting surface of the external magnetic source and the skin of the patient;

an adaptor having a skin-facing surface, the adaptor configured to engage the external magnetic source such that the skin-facing surface of the adaptor and the skin-contacting surface of the external magnetic source are oriented to face the same direction, the skin-facing surface of the adaptor defining an opening configured to receive a head of an ultrasound probe such that the ultrasound probe can contact the skin of the patient on which the skin-facing surface of the adaptor is disposed;

a tube having a distal end and a proximal end and a lumen extending therethrough, the distal end configured to be disposed within the stomach of a patient via the esophagus of the patient;

a balloon coupled to the distal end of the tube and having a balloon wall defining an interior in fluidic communication with the lumen, the balloon being inflatable with a fluid delivered via the lumen into an inflated condition, the interior defining an echogenic volume in the inflated condition of the balloon, the balloon configured to receive into the interior through the balloon wall a distal end of a guidewire received via the skin and stomach wall of the patient; and

a magnet coupled to one of the distal end of the tube and the balloon, a position of the balloon and the distal end of the tube within the stomach of the patient controllable via magnetic attraction between the magnet and the external magnetic source across the skin and stomach wall with the skin-contacting surface of the external magnetic source magnet in contact with the skin.

27. The system of claim 26, wherein:

the magnet is a first magnet, and

the external magnetic source includes a second magnet.

28. The system of claim 26, wherein the adaptor and the ultrasound probe are configured to be manually moved together by a user along the skin of the patient with the head of the ultrasound probe disposed within the opening of the adaptor and the skin-facing surface of the adaptor and the head of the ultrasound probe in contact with the skin of the patient.

29. The system of claim 26, wherein the adaptor is configured to engage the external magnetic source such that the skin-facing surface of the adaptor and the skin-contacting surface of the external magnetic source are disposed in parallel planes, the skin-contacting surface of the external magnetic source configured to be disposed in contact with the skin of the patient such that the magnetic attraction between the magnet and the external magnetic source across the skin and stomach wall draws the magnet toward the external magnetic source and the balloon toward the adaptor.

专利名称(译)	Coaptation超声装置和使用方法		
公开(公告)号	US10383595	公开(公告)日	2019-08-20
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[标]申请(专利权)人(译)	·乔佩罗STEVEN P		
当前申请(专利权)人(译)	马里兰州巴尔的摩大学		
[标]发明人	TROPELLO STEVEN P		
发明人	TROPELLO, STEVEN P.		
IPC分类号	A61B8/08 A61J15/00 A61M25/01 A61B8/00 A61B90/00 A61B17/00 A61B17/34 A61M25/10 A61B1/01 A61B1/00		
CPC分类号	A61B8/4209 A61B8/481 A61J15/0003 A61J15/0088 A61M25/0158 A61B8/0841 A61B2017/00876 A61B2017/3413 A61B2090/378 A61M25/10 A61M2025/0166 A61M2025/1079 A61B1/01 A61B1/00158		
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摘要(译)

公开了一种使用结合超声将细长医疗构件放置在患者体内的系统和方法，所述结合超声将磁引导与患者体内的医疗构件的超声可视化相结合。辅助超声探头适配器以足够的力磁性地吸引患者体内的细长医疗构件，以允许操作者手动地将构件引导至其预期位置。该适配器与超声波探头配合，为医疗操作员提供超声波对该部件位置的反馈，从而允许内部放置而无需更专业的医疗设备。

