Techniques for emergency apneic oxygenation include a cannula having a longitudinal inner passage with an inner diameter. A distal portion has a first outer diameter greater than the inner diameter, and is made of shape memory material shaped to bend in a first direction along the inner passage. A cannula base has a second outer diameter greater than the first outer diameter. A distance from a distal end of the cannula to a proximal end of the distal portion of the cannula is less than a distance from a surface of a throat of a subject to a distal surface of an airway of the subject. The inner passage is configured to pass a catheter connected at a proximal end to an oxygen source. In various embodiments, the cannula is used with a trocar and, optionally, a system base, or supplied in a kit with a catheter.
TECHNIQUES FOR EMERGENCY APNEIC OXYGENATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of Provisional Appln. 61/674,414, filed July 23, 2012, the entire contents of which are hereby incorporated by reference as if fully set forth herein, under 35 U.S.C. §119(e).

BACKGROUND OF THE INVENTION

[0002] Apnea refers to suspension of external breathing. During apnea there is little or no movement of the muscles of respiration and the volume of the lungs essentially remains unchanged. Severe tissue damage, brain damage and death can result. Oxygenation during apnea is called apneic oxygenation. Continuous apneic oxygenation delivered to the lower end of the trachea has been found to maintain trauma patients for up to one hour following injury. Despite these findings, there has yet to be an apneic oxygenation catheter developed for use in the field by emergency medical technicians (EMTs) or the military.

[0003] A cricothyrotomy is an incision through the cricothyroid membrane above the cricoid cartilage readily evident just above the trachea, and is considered less invasive than an incision through the trachea (tracheotomy) and to have fewer complications. Cricothyrotomy ventilation is often necessary to secure the airway in injuries requiring apneic oxygenation. When there is an obstruction in the airway and endotracheal intubation is not possible, an immediate solution is to insert a tube through a hole in the cricothyroid membrane. In some cases the bypass will allow the patient to breathe on their own. In other instances the bypass will provide an entry way for assisted ventilation and/or drug delivery.

[0004] Generally, the devices available to perform emergency cricothyrotomies require a skilled practitioner and require many steps to secure the airway. One example device and procedure are described in United States Patent number 4,677,978. There, a derivative of the Seldinger method is used making the installation of this device labor intensive. First, a scalpel is used to make an incision into the cricothyroid membrane. Next, an over-the-needle catheter is entered into the airway with a syringe. The syringe and needle are then removed,
leaving the catheter in place. Following that, a guide wire is inserted into the catheter, and the catheter is removed. Finally a dilator is inserted over the guide wire and the guide wire is removed.

[0005] Other devices such as those described in United States Patent number 4,869,718 do not use the Seldinger method and therefore require fewer steps. However, these devices only provide a small opening for the catheter and are limited to high frequency jet ventilation.
SUMMARY OF THE INVENTION

[0006] Techniques are provided for emergency apneic oxygenation, including devices that provide a more sustainable opening through the cricothyroid membrane.

[0007] In a first set of embodiments, a cannula for emergency apneic oxygenation includes a longitudinal inner passage having an inner diameter. A distal portion of the cannula is made of shape memory material shaped to bend in a first direction along the inner passage, and has a first outer diameter greater than the inner diameter. The cannula includes a cannula base having a second outer diameter greater than the first outer diameter. A distance from a distal end of the cannula to a proximal end of the distal portion of the cannula is less than a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject.

[0008] In some of embodiments of the first set, the first outer diameter is less than 10 millimeters.

[0009] In a second set of embodiments, a catheter for emergency apneic oxygenation includes a distal portion having a first outer diameter and a first longitudinal inner passage of a first inner diameter less than the first outer diameter. The catheter also includes a proximal portion configured at a proximal end for attachment to a fluid supply and having a second longitudinal inner passage in fluid communication with the first longitudinal inner passage. The catheter still further includes padding at the distal end of the distal portion configured to disperse fluid flow and to prevent damage to a lining of an airway of a target subject.

[0010] In some embodiments of the second set, the first outer diameter is less than 10 millimeters.

[0011] In some embodiments of the second set, the catheter includes a mark or a collar configured to be placed around the catheter at a particular distance to the proximal side from the distal end of the distal portion. The particular distance is approximately equal to a distance from an entry point into the airway of the target subject to a sub-segmented bronchus of the target subject. In some of these embodiments, the particular distance is in a range from about 5 centimeters to about 15 centimeters.
In a third set of embodiments, a trocar for emergency apneic oxygenation includes a distal portion comprising a tapered cutting edge and a penetration portion disposed proximal to the distal portion and having a diameter less than 10 millimeters. The trocar also includes a stop lip disposed proximal to the penetration portion and having a diameter greater than the diameter of the penetration portion. A distance from a distal end of the stop lip to a distal end of the distal portion is less than about a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject.

In a fourth set of embodiments, a system for emergency apneic oxygenation includes a cannula and a trocar. The cannula includes an inner passage of an inner diameter, a distal portion and a cannula base. The distal portion has a first outer diameter greater than the inner diameter, and is made of shape memory material shaped to bend in a first direction along the inner passage. The cannula base has a second outer diameter greater than the first outer diameter. The trocar includes a distal portion that includes a cutting edge, a penetration portion and a stop lip. The penetration portion is disposed proximal to the distal portion and has a diameter about equal to the inner diameter. The stop lip is disposed proximal to the penetration portion and has a diameter greater than the diameter of the penetration portion. The trocar is configured to engage the cannula by passing through the inner passage and straightening the bent distal portion of the cannula. When the trocar is engaged, a distance from a distal end of the distal portion of the trocar to a proximal end of the distal portion of the cannula is less than a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject.

In some embodiments of the fourth set, the system also includes a system base that has a system base opening that has a diameter about equal to the first outer diameter. The system base has an area outside the system base opening that is sufficient to inhibit the cannula base from passing into the airway of the target subject.

In some embodiments of the fourth set, the system also includes a catheter. The catheter is configured to pass through the inner passage of the cannula and be directed by the direction of the bent distal portion of the cannula down the airway of the target subject, after the cannula passes into the airway of the target subject and the trocar is removed.
In a fifth set of embodiments, a kit for emergency apneic oxygenation includes a cannula, a trocar, a base and a catheter. The cannula includes an inner passage of an inner diameter, a distal portion, and a cannula base. The distal portion has a first outer diameter greater than the inner diameter, and is made of shape memory material shaped to bend in a first direction along the inner passage. The cannula base has a second outer diameter greater than the first outer diameter. The trocar is configured to engage the cannula by passing through the inner passage and straightening the bent distal portion of the cannula. The system base has an opening about equal to the first outer diameter and is configured to be placed with the opening centered on an appropriate entry site on a target subject for the trocar engaged with the cannula. The catheter is configured to pass through the cannula after insertion of the cannula into the entry site by the engaged trocar and subsequent removal of the trocar. The catheter has a length that is at least a sum of a first distance from the entry site to a sub-segmented bronchus of the target subject and a second distance from the entry site to a supply of fluid.

In some embodiments of the fifth set, the first outer diameter is less than 10 millimeters.

In a sixth set of embodiments, a method for emergency apneic oxygenation includes cutting an opening of diameter less than 10 millimeters into an airway of a target subject at an entry site. The method also includes passing a distal end of a catheter through the opening and down the airway of the target subject to a sub-segmented bronchus of the target subject. The method further includes connecting a distal end of the catheter to a supply of oxygen and providing oxygen from the supply to the target subject at a rate sufficient to sustain life of the target subject.

Still other aspects, features, and advantages of the invention are readily apparent from the following detailed description, simply by illustrating a number of particular embodiments and implementations, including the best mode contemplated for carrying out the invention. The invention is also capable of other and different embodiments, and its several details can be modified in various obvious respects, all without departing from the
spirit and scope of the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.
BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

[0021] FIG. 1A through FIG. ID are block diagrams that illustrate example components of an apnea oxygenation kit, according to an embodiment;

[0022] FIG. 2A through FIG. 2D are block diagrams that illustrate example use of the components of FIG. 1A through FIG. ID, according to an embodiment;

[0023] FIG. 3A through FIG. 3E and FIG. 4 are block diagrams that illustrate example variations to the kit of FIG. 1A through FIG. ID, including a protective casing according to various embodiments;

[0024] FIG. 4A and FIG. 4B are block diagrams that illustrate a trocar with adjustable diameter cutting edge, according to an embodiment; and

[0025] FIG. 5A through FIG 5H are block diagrams that illustrate example variations in catheters from that depicted in FIG. ID, according to various embodiments.
DETAILED DESCRIPTION

[0026] A method, apparatus, system and kit are described for emergency apneic oxygenation. In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the present invention.

[0027] Some embodiments of the invention are described below in the context of an emergency, such as trauma caused by natural disasters, accidents, or acts of war or terror, suffered by an adult. However, the invention is not limited to this context. In other embodiments the procedure or device is employed on children and in clinical or hospital settings, such as in first aid, preparation for or recovery from surgery, or response to power failures in the operating room, or wherever cardiopulmonary resuscitation (CPR) or automated defibrillator is employed, such as for response to heart attack, pulmonary embolism, significant overwhelming infection, and choking.

[0028] As used herein, a "proximal" end or face shall be construed as the end or face that is closest to the user when the device is in use. As defined herein, a "distal" end or face shall be understood as the end or face that is closest to, or deepest inside, the patient, and farthest from the user, when the device is in use. As used herein, diameter refers to a shortest distance through an object, whether the object has a circular cross section or not. As used herein, a subject is a person or animal, and a target subject is a subject that is to receive apneic oxygenation. In some embodiments, the target subject is an individual person; in some embodiments, the target subject is a population of individuals, such as adults or sub-teenaged children. In such embodiments, the values of characteristics (such as values of airway diameter and length) of the target subject are an average or range of characteristics of the population. As used herein, a fluid means any material that flows at ambient temperatures, including liquids (e.g., medications) and gases (e.g., oxygen gas).
Although processes, equipment, and data structures are depicted in FIG. 1 as integral blocks in a particular arrangement for purposes of illustration, in other embodiments one or more processes or data structures, or portions thereof, are arranged in a different manner, on the same or different hosts, in one or more databases, or are omitted, or one or more different processes or data structures are included on the same or different hosts.
FIG. 1A through FIG. 1D are block diagrams that illustrate example components of an apnea oxygenation kit, according to an embodiment. In the illustrated embodiment, the components of the kit are shown with circular cross sections; however, in other embodiments other cross sections are used, such as oval cross sections, polygonal cross sections, lens shaped cross sections, and rectilinear cross sections.

FIG. 1A is a block diagram that illustrates an example cross section through a cannula 110 with an inner passage of inner diameter 116 configured for passing one or more catheters. The cannula 110 is configured to be inserted through a wall at the front of the target subject's airway, e.g., above the cricoid cartilage, and into the target subject's airway. Thus it extends from the skin surface of a throat of a target subject into the airway.

A distal portion 112 of the cannula is made of a shape memory material and is bent in a first direction (downward in the illustrated view) as one progresses through the inner passage from a proximal end to a distal end. The distal portion 112 has an outer diameter 117, larger than the inner diameter 116. At the proximal end of cannula 110 is a cannula base 114, with an outer diameter greater than the outer diameter 117 of the distal portion 112 of the cannula. In some embodiments, there is a straight portion 115 of the cannula between the bent distal portion 112 and the cannula base portion 112. Suitable shape memory materials are known in the art, for example, titanium, thin stainless steel, and nickel titanium alloy (also called Nitinol). When in place in the wall of a target subject's airway, the downward bend of the distal portion 112 of the cannula directs a catheter threaded through the cannula downward in the subject's airways toward the lungs. This downward bias provides a very advantageous control when an operator is working in unguided and difficult conditions, such as darkness. The larger outer diameter of the cannula base 114 prevents the cannula 110 from falling through a hole with a diameter closely matching the outer diameter 117 of the distal portion 112 of the cannula, while allowing the entire distal portion 112, and in some embodiments, a straight portion 115 to pass into the hole. A the cannula base 114 has thickness 118 and is made of any suitable rigid or semi-rigid material including the same materials as the distal portion or separate materials such as stainless steel, titanium, nitinol, plastics or other types of polymers, or some combination.
[0033] Thus, FIG. 1A depicts a cannula that includes an inner passage of an inner diameter 116, a distal portion 112 and a cannula base 114. The distal portion 112 has a first outer diameter greater 117 than the inner diameter 116. The cannula 110 is shaped in the distal portion 112 to bend in a first (downward) direction along the inner passage. The distal portion 112 is made of shape memory material. The cannula base 114 has a second outer diameter greater than the first outer diameter 117. In some embodiments, the cannula includes a straight portion 115 between the cannula base 114 and the distal portion 112, with an outer diameter about equal to the first outer diameter 117.

[0034] It is also desirable that the bend in the cannula take place within the airway of the target subject without contacting or penetrating the back wall of the airway. Thus, it is advantageous for a distance 119 from a distal end of the cannula to a proximal end of the distal portion 112 of the cannula to be less than a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject. In some embodiments, the length of the distal portion 112 is so constrained. In some embodiments in which the distal face of the cannula base 114 is flush with the skin of the target subject, the distance from the distal face of cannula base 114 to the distal end of the cannula is advantageously less than the distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject to avoid damaging or perforating the back wall of the airway.

[0035] Currently, apneic oxygenation uses holes into the airway which are a centimeter (10 millimeters) or more. Preferably, smaller incisions are made to reduce blood loss and chances for complications such as infection. By passing catheters attached to oxygen supply, smaller opening can be used. Thus, in various embodiments, the outer diameter 117 of the distal portion of the cannula is less than 10 millimeters and preferable in a range from about 3 millimeters to about 4 millimeters. The inner diameter 116 is sufficient to pass at least one catheter to supply oxygen and is preferably in a range from about 2 millimeters to about 3 millimeters. Larger inner diameters are used for bigger catheters or for multiple catheters, in various embodiments.
FIG. 1B is a block diagram that illustrates an example trocar 120, according to an embodiment. Trocar 120 (also called an obturator) is used to cut a hole from the skin of the throat into the airway of the target subject without damaging the back wall of the airway of the target subject. The trocar is made of any suitable rigid material, such as stainless steel, carbon steel, titanium, cobalt chrome, plastics or other types of polymers, or some combination. The trocar 120 is further configured to leave the cannula in place in the hole so cut. In the illustrated embodiment, the trocar includes a tapered piercing tip 124 at a distal end and a penetration portion 122 disposed proximal to the distal portion 124 and having a diameter 123 about equal to an inner diameter 116 of the cannula 110. Thus the diameter 123 is less than about 10 millimeters and preferably less than 4 millimeters, and most preferably for use with a single catheter in a range from about 2 millimeters to about 3 millimeters. Piercing tip 124 is generally conical in shape. However, in some embodiments the piercing tip has more than one cutting edge. The trocar 120 also includes a stop lip 128 disposed proximal to the penetration portion and having a diameter greater than the diameter of the penetration portion. The stop lip 128 is configured to keep a cannula 110 from sliding along the trocar during insertion. In some embodiments, proximal to the stop lip is a handle 126 that is more easily grasped by an operator.
To keep from damaging a back wall of the airway of the target subject, a distance 127 from a distal end of the stop lip 128 to a distal end of the distal portion is less than a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject. In some embodiments, in which the cannula 110 with base of thickness 118 is disposed distal to the stop lip, a distance 127 minus distance 118 is constrained to be less than the distance from the skin of the throat to the back wall of the airway. In some embodiments, in which the cannula 110 with base of thickness 118 and system base of thickness $t_{sb}$ is disposed distal to the stop lip and cannula base 114, a distance 127 minus distance 118 and minus $t_{sb}$ is constrained to be less than the distance from the skin of the throat to the back wall of the airway. In various embodiments, depending on the target patient, the distance 127 is selected in a range from about 5 millimeters to about 35 millimeters, and preferably about 25 millimeters. The trocar 120 is configured to engage the cannula 110 by passing the distal end 124 of the trocar through the inner passage of the cannula base 114 and hence into the inner passage of the bent distal portion 112, and straightening the bent distal portion 112 of the cannula.

FIG. 1C is a block diagram that illustrates an example system base 130, according to an embodiment. System base 130 has diameter 131 and includes a system base opening 132 of diameter about equal to the outer diameter 117 of cannula 110. As shown in FIG.2A, system base also has thickness 134. The system base 130 has an area outside the system base opening 132 that is sufficient to inhibit the cannula base 114 from passing into the airway of the target subject. The system base 130 also provides an advantage of locating the entry point incision on the throat of the target subject as a center of the opening 132. The system base 130 is made of any suitable rigid or semi-rigid material, including molded plastic, other types of polymers, stainless steel, titanium, or cobalt chrome, or some combination. In various embodiments, the system base has a diameter in a range from about 5 centimeters to about 15 centimeters. Although appearing circular in FIG. 1C, in various other embodiments, the system base 130 has a different shape, such as a rectangle or shape to match the contours of the neck of the target subject.
[0039] FIG. 1D is a block diagram that illustrates an example catheter 140, according to an embodiment. Catheter 140 is a long tube 142 of flexible non-toxic and sterile material, such as silicon plastic or other types of polymers with a fitting 144 for attachment to fluid supply, such as an oxygen supply or a medicine supply. A tube with outer diameter of 2 to 3 millimeters was found suitable for delivering sufficient oxygen to a target subject without exposing the subject to the risks associated with a larger opening, including excessive bleeding, infection and loss of life. The inner diameter is selected in a range from about 1 millimeter to about 2 millimeters. A distal portion is configured to be inserted into an airway of the subject patient and a distal end open to allow free fluid flow, for example into a sub-segmented bronchus of the target subject. A proximal end is configured for attachment to a fluid supply such as an oxygen supply or medicine supply. A proximal portion connects an entry point into the airway of the target subject to the proximal end and also comprises a second inner and outer diameter that are the same as in the distal portion in some embodiments, and different in other embodiments. The second longitudinal inner passage is in fluid communication with the first longitudinal inner passage.

[0040] In other embodiments, the kit includes additional or fewer components. For example, in some embodiments, the cannula base 114 has an outer diameter sufficient to prevent falling into any opening for the distal portion 112, and the system base is omitted. In various other embodiments, other components are added, such as those described in more detail below.

[0041] FIG. 2A through FIG. 2D are block diagrams that illustrate example use of the components of FIG. 1A through FIG. 1D, according to an embodiment. As shown in FIG. 2A, a cross section of the throat of a target subject is illustrated by skin 210, front wall 212 of airway, and airway 220 having width 222. The system base 130 of thickness 134 is laid on the skin 210 of the subject to expose in opening 132 an entry point 230 for the incision. A distance 224 extends from the distal face of the system base 130 to the back wall of the airway; and a distance 223 extends from the proximal face of the system base 130 to the back wall of the airway.
The trocar 120 has engaged the cannula 110 and straightened the bent distal portion. The proximal face of the cannula base 114 is flush with the distal face of the stop lip 128. The incision is made by driving the trocar engaged with the cannula in the direction of the open arrow.

As shown in FIG. 2B, the trocar 120 cuts through the skin 210 and front wall 212 of the target subject airway 220 with the cannula 110 in place. The back wall of the airway is not disturbed so long as the distance from the distal end of trocar to the stop lip 137 minus the thickness 118 of the cannula base minus the thickness 134 of the system base is less than the distance from the skin 210 to the back wall of the airway 220. In some embodiments, markings on cannula base 114 indicate the direction of bending of the cannula with the trocar disengaged. This mark is oriented so that the cannula 110 will bend downward when the trocar is removed.

As shown in FIG. 2C, the trocar 120 is removed from the entry site by pulling on handle 126 in the direction of the open arrow. In some embodiments, the base 114 of cannula is held in place while the trocar 120 is removed. The system base 130 prevents the base 114 of cannula 110 from entering the hole made by the cutting edge of the trocar 120. With the trocar disengaged, the distal portion of cannula 110 assumes its original shape, and points downward in the airway towards the lungs of the target subject, as desired.

As shown in FIG. 2D, a catheter 140 is inserted through the inner passage of the cannula 110 and is automatically directed downward inside the airway toward the lung because the cannula has remembered its downward bent shape.
FIG. 3A through FIG. 3E and FIG. 4 are block diagrams that illustrate example variations to the kit of FIG. 1A through FIG. 1D, including a protective casing, according to various embodiments. In some embodiments the device further comprises a protective casing 350. Once the body cavity is penetrated FIG. 3B, the trocar 120 and optional protective casing 140 may be removed. The catheter 110 and base 130 remain in place. In these embodiments, the trocar includes a locking disk 321 that has a diameter larger than stop lip 128. The diameter and length depend on dimensions of any securing mechanism 352 and 354 on the protective casing. The preferred dimensions fix locking disk 321 into the securing mechanism 352 and 354 when in place.

Referring to FIG. 3C, the protective casing 350 comprises an outer casing 351, a securing mechanism 320 for the locking ring of the obturator, and one or more fasteners 352 and 354. Outer casing 351 is made of a generally rigid material, such as metal, plastics or other types of polymers, and has an outer diameter of between about 0.5 centimeters to about 4 centimeters. The interior diameter of outer casing 351 is between about 0.49 centimeters and about 3.99 centimeters. The length of outer casing 351 is between about 0.5 centimeters to about 4 centimeters. Securing mechanism 352 and 354 is located somewhere along the interior surface of the outer casing 351. Securing mechanism 352 and 354 may cover the entire circumference of the outer casing 351 or there may be one or more parts spaced around the circumference of the outer casing 351. The purpose of the securing mechanism is to fix the locking ring of the trocar in place when the trocar tip is inserted into the subject. The securing mechanism also serves as a safety mechanism to prevent the user from pressing the trocar too far into the subject.

In some embodiments the securing mechanism 352 and 354 is located at different locations on the outer casing shaft to conform to different patient sizes. In other embodiments, the locking ring is fixed by the securing mechanism 352 and 354 before the snaps of the cannula are fixed to the base. For these embodiments, the cannula is preferably manually fixed after the trocar and protective casing are removed. It is contemplated that this embodiment will provide for a longer cannula without risking unwanted damage by the trocar.
Referring to FIG. 3C, one or more fasteners 356 are located at the base of the protective casing. The fasteners 356 are used to secure the protective casing 350 to the base as depicted in FIG. 3A and FIG. 3B. In one embodiment, the protective casing 350 is removed from the base by rotating the protective casing 350. In this example the rotation frees the one or more fasteners 356 from the base. Other types of fasteners may be used instead. For example, the fasteners 356 may snap into the base.

FIG. 3D depicts a proximal face of the system base 330. The base 330 comprises a generally disk shaped surface 410. Base 330 further comprises one or more notches 332 for the fasteners of the outer casing. The shape of the notches 332 depends on the configuration of the protective casing fasteners. In one example embodiment the notches 332 are L-shaped to allow for the release of the protective casing when the protective casing is rotated. In some embodiments, the base 330 also comprises of one or more notches 333 which receive one or more snaps 312 of the cannula 310 as depicted in FIG. 3E. The specific configuration of notches 332 and 333 may vary in other embodiments. In consideration of the teaching provided herein, one having ordinary skill in the art would recognize other configurations that while not specifically identified, are still within the overall spirit and scope of this invention.

Referring again to FIG. 3D, in some embodiments the system base 330 is attached to a strap 336 that wraps around the neck of the target subject, and is held in place by complementary buckle 338a and clasp 338b. In some embodiments, strap 336 is attached to system base 330 by eyelets that form part of base 330. In the illustrated embodiment, the system base 330 includes an inner annulus 334 that is slightly recessed for accepting the distal face of cannula base 114.
FIG. 4 depicts a distal face of the system base 330, according to some embodiments. In the illustrated embodiment, the distal face is contoured with one or more contours 339 so that the system base 330 settles most securely when the opening of the system base is properly positioned over a preferred entry point. Thus, a system base is configured with a shape that follows contours of a throat of the target subject so that the system opening is centered on a location appropriate as an entry site for a catheter for emergency apneic oxygenation.

FIG. 5A through FIG. 5H are block diagrams that illustrate example variations in catheters from that depicted in FIG. ID, according to various embodiments. FIG. 5A is a block diagram that illustrates an apneic oxygenation catheter 500 according to an embodiment. Catheter 500 comprises an elongated shaft 501, having a proximal end 519 and a distal end 509. Catheter 500 further comprises one or more ventilation ports called apertures 506 at the distal portion of the shaft and a connection element 514 at the proximal end. The connection element 514 is depicted connected to a fluid supply tank 518, such as an oxygen supply tank. Apertures 506 may be located in any pattern desirable. For example, in some embodiments a plurality of apertures are located within a particular distance of the distal end of the distal portion, wherein each aperture is configured to permit fluid flow between the first longitudinal inner passage and an outside of the catheter. In some of these embodiments, the particular distance is less than a distance from a sub-segmented bronchus of the target subject to a mainstem bronchus of the target subject.
In some embodiments, the catheter 500 includes a collar 516 to mark the desired length 507 of the catheter to be inserted through the cannula and into the airway of the target subject. The collar is configured to be placed around the catheter at a particular distance 507 to the proximal side from the distal end of the distal portion, wherein the particular distance 507 is approximately equal to a distance from an entry point into the airway of the target subject to a sub-segmented bronchus of the target subject. In some embodiments, the particular distance is in a range from about 5 centimeters to about 15 centimeters. In some embodiments, the collar is moveable along that range. In some embodiments, gradation marks are included along the shaft in addition to or instead of the collar 516. An advantage of the collar 516 is that the collar presents a physical stop when it encounters the cannula. This physical stop allows an operator to detect, without having to look at the catheter, when sufficient length has been inserted into the airway. In some embodiments, the inner and outer diameter of the catheter have one set of values on a distal portion 502 to the distal side of the collar 516, and another set of values on a proximal portion 512 to the proximal side of the collar 516.

Oxygenation catheter 500 advantageously includes padding 504 at the distal end. Padding 504 in various embodiments includes, for example, a balloon, a sponge, or other attachment that would help prevent injury to the trachea or bronchi during insertion or dispense air in 360 degrees or both, in some combination. In some embodiments, a dissolvable capsule at the distal end is used to reduce the risk of injury when the device is inserted, alone or in combination with the padding.

Catheter 500 may further comprise one or more balloon 508 along the shaft 502. The purpose of balloon 508 is to secure the device in the patient, in some embodiments; or to concentrate the oxygen to a certain area of the lungs, in some embodiments. The one or more balloons 508 may be located at various locations along the length of shaft 502 depending on the particular needs. Balloon 508 may be inflated using the oxygen source or it may have a separate lumen in which a separate inflation device is attached.
The apneic oxygenation catheter may have more than one lumen. FIG. 5B depicts a quadruple lumen embodiment 520 having a drug delivery lumen 522a and an oxygen delivery lumen 522b inside catheter sheath 524 with apertures 526 into the lumen 522b. In other embodiments, the catheter may have one, two, three or more lumens. The proximal end of drug delivery lumen 522a is configured to be readily attached to containers 526 of drugs. Catheter 520 in some embodiments further comprises a fenestrated diaphragm 528 inside drug delivery lumen 522a. Diaphragm 528 enables small drug particle dispersion for better lung absorption. Example drugs that may be used include, but are not limited to, epinephrine, atropine, and lidocaine. Thus, each of the first longitudinal inner passage in a distal portion and the second longitudinal inner passage in a proximal portion is divided into a plurality of lumens, each lumen in the first longitudinal passage in fluid communication with a corresponding lumen in the second longitudinal passage.

The oxygenation catheter may also have a bifurcated or trifurcated distal end, below a catheter sheath, to provide for additional oxygenation. FIG. 5C is a block diagram that illustrates an example trifurcated catheter 530 with three lumens 532a, 532b and 532c, each configured with connectors 535a, 535b, 535c, respectively, for connecting to a fluid supply tanks, such as an oxygen tank. FIG. 5F is a block diagram that illustrates an example trifurcated catheter 544 deployed in a lung 590. The branch may be located at the base of the trachea or further down in the lung 590. FIG. 5F depicts a branch in one mainstem bronchus, with each different lumen 542a, 542b, 542c, located in a different sub-segmented bronchus of bronchi 593a, 593b, 593c, respectively.
Referring now to FIG. 5D and FIG. 5F, one possible deployment method for the trifurcated system is a pull string. In FIG. 5D separate lumen 542a, 542b, 542c with connectors 545a, 545b, 545c, respectively, are controlled at the distal end by pull string ring 546 connected to pull strings 547. When pulled, the strings 547 retract a sheath 544 of the catheter, exposing each lumen in succession. By feel, the operator may leave one lumen near each of different sub-segmented bronchi. In FIG. 5E, separate lumen 552a, 552b, 552c with connectors 555a, 555b, 555c, respectively, within sheath 554, are controlled at the distal end by pull string ring 556 connected to pull strings 557. When pulled, the strings 557 retract each lumen in succession. Here, each of one or more distal ends (branches) is connected to a pull string 557 to coordinate the deployment of each distal end of lumen 552a, 552b, 552c.

FIG. 5G is a block diagram that illustrates an example alternative securing mechanism to the balloon 508 of FIG. 5A. Catheter 570 includes a shaft 572 and expandable device 574a connected by guide wire 577 to ring 576. When ring 576 is pulled, expandable device 574a expands. Expandable device 574a is used to anchor the catheter 570 in the airway of the target subject, as depicted in FIG. 5H. FIG. 5H is a block diagram that illustrates an example location of catheter shaft 572 and expanding device 574b in an expanded configuration in a lung 590 of a target subject. The distal end of shaft 572 is located in sub-segmented bronchus 593b of sub-segmented bronchi 593a, 593b, 593c. In an example embodiment, expandable device 574a is made of nitinol. However, other biocompatible materials, such as metals, plastics or other polymers, or some combination, are used in other embodiments. In some embodiments, expandable device 574a is a silicon balloon or similar type feature is used. Catheter 570 further comprises a guide wire channel in some embodiments.

Thus various embodiments include an anchoring device disposed outside the catheter at a particular distance proximal to the distal end of the distal portion of the catheter, wherein the anchoring device is configured to assume a first shape of small cross sectional area and a second shape of larger cross sectional area sufficient to fill the airway of the target subject outside the catheter.
Various combinations of the devices described above may be combined into a kit for emergency use. In addition to the oxygenation catheter and a cannula-trocar crycothyrotomy intubation assembly, a kit may further comprise an oxygen source. It is contemplated that an oxygen tank capable of containing enough oxygen to maintain an average sized patient for at least an hour would be preferable. However, larger or smaller tanks may be used in the kit. A person having ordinary skill in the art would be capable of determining the most appropriate tank size. In some example embodiments, vials of drugs such as, for instance, epinephrine, atropine, or lidocaine are provided with the kit.

A method is described for providing apneic oxygenation, according to some embodiments. Although steps are described 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. A method for emergency apneic oxygenation includes cutting an opening of diameter less than 10 millimeters into an airway of a target subject at an entry site. The method also includes passing a distal end of a catheter through the opening and down the airway of the target subject to a sub-segmented bronchus of the target subject. The method still further includes connecting a distal end of the catheter to a supply of oxygen, and providing oxygen from the supply to the target subject at a rate sufficient to sustain life of the target subject.

In some embodiments, cutting the opening further comprises inserting at the entry site a trocar engaged with a cannula comprising a distal end of shape memory material, wherein the cannula without trocar engaged is bent in a first direction. The trocar is inserted so that the first direction is directed downward in the airway of the target subject. The step further includes removing the trocar while leaving the cannula inserted at the entry site.

In some embodiments, inserting the trocar engaged with the cannula at the entry site further includes placing a system base on a throat of the target subject so that an opening of the system base is centered on the entry site, and inserting the trocar engaged with the cannula through the opening in the system base.
In some embodiments, passing the distal end of the catheter through the opening further comprises passing the distal end of the catheter through the cannula.

In some embodiments, the opening into the airway of the target subject is in a range from about 2 millimeters to about 3 millimeters.

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 items, elements or steps modified by the article.
CLAIMS

What is claimed is:

1. A cannula for emergency apneic oxygenation comprising:
   a longitudinal inner passage having an inner diameter;
   a distal portion having a first outer diameter greater than the inner diameter, wherein the cannula is shaped in the distal portion to bend in a first direction along the inner passage, and wherein the distal portion is made of shape memory material; and
   a cannula base having a second outer diameter greater than the first outer diameter, wherein
   a distance from a distal end of the cannula to a proximal end of the distal portion of the cannula is less than a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject, and
   the inner passage is configured to pass a catheter connected at a proximal end to an oxygen source.

2. A cannula as recited in claim 1, wherein the first outer diameter is less than 10 millimeters.

3. A cannula as recited in claim 1, wherein the first outer diameter is in a range from about 3 millimeters to about 4 millimeters and the inner diameter is in a range from about 2 millimeters to about 3 millimeters.

4. A cannula as recited in claim 1, further comprising a straight portion between the cannula base and the distal portion, wherein a diameter of the straight portion is about equal to the first outer diameter.
5. A cannula as recited in claim 1, wherein the distal portion of the cannula is configured to pass through an opening in a system base that has an area outside the first diameter that is sufficient to keep the cannula base from passing into the airway of the target subject, wherein the opening in the system base has a diameter about equal to the first outer diameter.

6. A cannula as recited in claim 5, wherein a distal face of the cannula base is configured to attach to a proximal face of the system base outside the opening in the system base.

7. A catheter for emergency apneic oxygenation comprising:
   a distal portion having a first outer diameter and a first longitudinal inner passage of a first inner diameter less than the first outer diameter;
   a proximal portion configured at a proximal end for attachment to a supply of fluid and having a second longitudinal inner passage in fluid communication with the first longitudinal inner passage; and
   padding at the distal end of the distal portion configured to disperse fluid flow and to prevent damage to a lining of an airway of a target subject.

8. A catheter as recited in claim 7, wherein the first outer diameter is less than about 10 millimeters.

9. A catheter as recited in claim 7, wherein the first outer diameter is in a range from about 2 millimeters to about 3 millimeters.

10. A catheter as recited in claim 7, wherein the padding is configured to disperse fluid flow through 360 degrees.
11. A catheter as recited in claim 7, further comprising a mark or a collar configured to be placed around the catheter at a particular distance to the proximal side from the distal end of the distal portion, wherein the particular distance is approximately equal to a distance from an entry point into the airway of the target subject to a sub-segmented bronchus of the target subject.

12. A catheter as recited in claim 11, wherein the particular distance is in a range from about 5 centimeters to about 15 centimeters.

13. A catheter as recited in claim 7, further comprising an anchoring device disposed outside the catheter at a particular distance proximal to the distal end of the distal portion of the catheter, wherein the anchoring device is configured to assume a first shape of small cross sectional area and a second shape of larger cross sectional area sufficient to fill the airway of the target subject outside the catheter.

14. A catheter as recited in claim 13, wherein the particular distance is less than a distance from an entry point into the airway of the target subject to a sub-segmented bronchus of the target subject.

15. A catheter as recited in claim 7, further comprising a plurality of apertures within a particular distance of the distal end of the distal portion, wherein each aperture is configured to permit fluid flow between the first longitudinal inner passage and an outside of the catheter.

16. A catheter as recited in claim 15, wherein the particular distance is less than a distance from a sub-segmented bronchus of the target subject to a mainstem bronchus of the target subject.
17. A catheter as recited in claim 7, wherein each of the first longitudinal inner passage and the second longitudinal inner passage is divided into a plurality of lumens, each lumen in the first longitudinal passage in fluid communication with a corresponding lumen in the second longitudinal passage.

18. A catheter as recited in claim 17, wherein at least one lumen of the plurality of lumens is configured for attachment to a supply of medicine.

19. A catheter as recited in claim 7, wherein the supply of fluid is a supply of oxygen gas.

20. A trocar for emergency apneic oxygenation comprising:
   a distal portion comprising a tapered cutting edge;
   a penetration portion disposed proximal to the distal portion and having a diameter less than 10 millimeters; and
   a stop lip disposed proximal to the penetration portion and having a diameter greater than the diameter of the penetration portion,
   wherein
   a distance from a distal end of the stop lip to a distal end of the distal portion is less than about a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject.

21. A trocar as recited in claim 20, wherein the diameter is in a range from about 2 millimeters to about 3 millimeters.
22. A system for emergency apneic oxygenation comprising:

- a cannula comprising
  - an inner passage of an inner diameter,
  - a distal portion having a first outer diameter greater than the inner diameter, wherein
    the cannula is shaped in the distal portion to bend in a first direction along the
    inner passage, and wherein the distal portion is made of shape memory material,
  - and
  - a cannula base having a second outer diameter greater than the first outer diameter;

- a trocar comprising
  - a distal portion comprising a tapered cutting edge;
  - a penetration portion disposed proximal to the distal portion and having a diameter about equal to the inner diameter; and
  - a stop lip disposed proximal to the penetration portion and having a diameter greater than the diameter of the penetration portion,

wherein

- the trocar is configured to engage the cannula by passing through the inner passage and straightening the bent distal portion of the cannula,
- when the trocar is engaged, a distance from a distal end of the distal portion of the trocar to a proximal end of the distal portion of the cannula is less than a distance from a surface of a throat of a target subject to a distal surface of an airway of the target subject.

23. A system as recited in claim 22, further comprising a system base that has a system base opening that has a diameter about equal to the first outer diameter, wherein the system base has an area outside the system base opening that is sufficient to inhibit the cannula base from passing into the airway of the target subject.
24. A system as recited in claim 23, wherein the system base is configured with a shape that follows contours of a throat of the target subject so that the system opening is centered on a location appropriate as an entry site for a catheter for emergency apneic oxygenation.

25. A system as recited in claim 22, further comprising a catheter configured to pass through the inner passage of the cannula and be directed by the direction of the bent distal portion of the cannula down the airway of the target subject after the cannula passes into the airway of the target subject and the trocar is removed.

26. A kit for emergency apneic oxygenation comprising:
   a cannula comprising
      an inner passage of an inner diameter,
      a distal portion having a first outer diameter greater than the inner diameter, wherein
      the cannula is shaped in the distal portion to bend in a first direction along the
      inner passage, and wherein the distal portion is made of shape memory material,
      and
      a cannula base having a second outer diameter greater than the first outer diameter;
   a trocar configured to engage the cannula by passing through the inner passage and
   straightening the bent distal portion of the cannula;
   a system base having an opening about equal to the first outer diameter and configured to
   be placed with the opening centered on an appropriate entry site on a target subject
   for the trocar engaged with the cannula; and
   a catheter configured to pass through the cannula after insertion of the cannula into the
   entry site by the engaged trocar and subsequent removal of the trocar, wherein the
   catheter has a length that is at least a sum of a first distance from the entry site to a
   sub-segmented bronchus of the target subject and a second distance from the entry
   site to a supply of fluid.

27. A kit as recited in claim 26, wherein the first outer diameter is less than 10 millimeters.
28. A kit as recited in claim 26, wherein the inner diameter is in a range from about 2 to about 3 millimeters.

29. A kit as recited in claim 26, wherein, when the trocar engaged with the cannula is disposed through the system base, a distance from the distal face of the system base to a distal end of the trocar is less than a distance from a surface of a throat of the target subject to a distal surface of an airway of the target subject.

30. A kit as recited in claim 26, wherein the fluid is oxygen.

31. A kit as recited in claim 26, wherein the catheter is divided into a plurality of lumen.

32. A kit as recited in claim 26, wherein the catheter is one of a plurality of catheters encompassed by a sheath, and the inner diameter of the cannula is not less than a diameter of the sheath.

33. A kit as recited in claim 32, wherein corresponding distal ends of the plurality of catheters are configured to be separated to each enter a corresponding sub-segmented bronchus when the cannula is deployed in the airway of the target subject and the sheath is configured through the inner passage of the cannula.

34. A method for emergency apneic oxygenation comprising:
   cutting an opening of diameter less than 10 millimeters into an airway of a target subject at an entry site;
   passing a distal end of a catheter through the opening and down the airway of the target subject to a sub-segmented bronchus of the target subject;
   connecting a distal end of the catheter to a supply of oxygen;
   providing oxygen from the supply to the target subject at a rate sufficient to sustain life of the target subject.
35. A method as recited in claim 34, wherein cutting the opening further comprises:
   inserting at the entry site a trocar engaged with a cannula comprising a distal end of shape
   memory material, wherein the cannula without trocar engaged is bent in a first
   direction and the trocar is inserted so that the first direction is directed downward in
   the airway of the target subject; and
   removing the trocar while leaving the cannula inserted at the entry site.

36. A method as recited in claim 35, wherein inserting at the entry site the trocar engaged
   with the cannula further comprises:
   placing a system base on a throat of the target subject so that an opening of the system
   base is centered on the entry site; and
   inserting the trocar engaged with the cannula through the opening in the system base.

37. A method as recited in claim 35, wherein passing the distal end of the catheter through
   the opening further comprises passing the distal end of the catheter through the cannula.

38. A method as recited in claim 35, wherein the opening into the airway of the target subject
   is in a range from about 2 millimeters to about 3 millimeters.
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/051739

A. CLASSIFICATION OF SUBJECT MATTER
A61M 16/04(2006.01)i, A61M 25/01(2006.01)i, A61M 25/088(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61M 16/04; A61M 16/10; A61M 16/00; A61M 25/01; A61M 25/088

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: cecothyrotomy, cricoid, trachea, ventilation, gas, oxygen, trocar, cannula, shape memory, catheter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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<td>US 2009-0260625 A1 (HONDRA, A. S.) 22 October 2009 See abstract; claims 34, 41, 46; paragraphs [0060], [0066], [0069], [0070]; figures s, 9A-9B, 10w, 10k, 11.</td>
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<td>US 5967143 A (KLAPFENBERGER, J.) 19 October 1999 See claim 1; figures 1A-1B, 2A.</td>
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<tr>
<td>A</td>
<td>US 3441061 B2 (WOOD, S. D.) 11 March 2008 See abstract; claim 1; figures 2-3.</td>
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<td>A</td>
<td>US 4677978 A (MELKER, R. J.) 7 July 1987 See abstract; claim 1; figures 5-8.</td>
<td>1-33</td>
</tr>
<tr>
<td>A</td>
<td>US 2012-0145147 A1 (FREITAG, L. et al.) 14 June 2012 See abstract; claims 1-3; figure 2.</td>
<td>1-33</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
  "O" document referring to an oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed
  "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  "&" document member of the same patent family

Date of the actual completion of the international search 23 October 2013 (23.10.2013)
Date of mailing of the international search report 24 October 2013 (24.10.2013)

Name and mailing address of the ISA/KR
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Form PCT/ISA/210 (second sheet) (July 2009)
**INTERNATIONAL SEARCH REPORT**

**International application No.**
PCT/US2013/051739

**Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. **X** Claims Nos.: 34-38
   - because they relate to subject matter not required to be searched by this Authority, namely:
     - Claims 34-38 pertain to methods for treatment of the human and thus relate to a subject-matter which this International Searching Authority is not required, under Article 17(2)(a)(i) of the PCT and Rule 39(l)(iv) of the Regulations under the PCT, to search.

2. **☐** Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. **☐** Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

1. **☐** As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. **☐** As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. **☐** As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. **☐** No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

- **☐** The additional search fees were accompanied by the applicant’s protest and, where applicable, the payment of a protest fee.
- **☐** The additional search fees were accompanied by the applicant’s protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- **☐** No protest accompanied the payment of additional search fees.
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<tr>
<td>US 2009-0260625 A</td>
<td>22/10/2009</td>
<td>CA 2535450 Al</td>
<td>17/02/2005</td>
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<tr>
<td></td>
<td></td>
<td>CA 2623756 Al</td>
<td>29/03/2007</td>
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<tr>
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<td></td>
<td>CN 101454041 A</td>
<td>10/06/2009</td>
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<td></td>
<td>CN 101454041 B</td>
<td>12/12/2012</td>
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<tr>
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<td></td>
<td>CN 102416213 A</td>
<td>18/04/2012</td>
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<tr>
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<td></td>
<td>EP 1654023 A2</td>
<td>10/05/2006</td>
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<td></td>
<td></td>
<td>EP 1926517 A2</td>
<td>04/06/2008</td>
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<td></td>
<td>EP 2068992 A2</td>
<td>17/06/2009</td>
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<td>JP 2007-501666 A</td>
<td>01/02/2007</td>
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<td></td>
<td>JP 2009-508645 A</td>
<td>05/03/2009</td>
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<td>JP 2013-031758 A</td>
<td>14/02/2013</td>
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<td>US 2005-0005936 Al</td>
<td>13/01/2005</td>
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<td>US 2005-0034721 Al</td>
<td>17/02/2005</td>
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<td>US 2008-0041371 Al</td>
<td>21/02/2008</td>
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<td>US 2008-0135044 Al</td>
<td>12/06/2008</td>
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<td>US 2009-0107494 Al</td>
<td>30/04/2009</td>
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<td>US 2009-0151726 Al</td>
<td>18/06/2009</td>
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<td></td>
<td>US 2009-0255533 Al</td>
<td>15/10/2009</td>
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<tr>
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<td>US 2010-0252043 Al</td>
<td>07/10/2010</td>
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<tr>
<td></td>
<td></td>
<td>US 2010-0269834 Al</td>
<td>28/10/2010</td>
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<td></td>
<td>US 2011-0209705 Al</td>
<td>01/09/2011</td>
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<td>US 2013-019864 Al</td>
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<tr>
<td></td>
<td></td>
<td>US 7487778 B2</td>
<td>10/02/2009</td>
</tr>
<tr>
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<td></td>
<td>US 7533670 Bl</td>
<td>19/05/2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 8381729 B2</td>
<td>26/02/2013</td>
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<td></td>
<td></td>
<td>US 8418694 B2</td>
<td>16/04/2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2005-014091 A2</td>
<td>17/02/2005</td>
</tr>
<tr>
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<td></td>
<td>WO 2005-014091 A3</td>
<td>17/03/2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2007-035804 A3</td>
<td>31/05/2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2008-019102 A2</td>
<td>14/02/2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2008-019102 A3</td>
<td>03/07/2008</td>
</tr>
<tr>
<td>US 5967143 A</td>
<td>19/10/1999</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1824567 A4</td>
<td>08/04/2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2006-0124134 Al</td>
<td>15/06/2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2006-065554 A2</td>
<td>22/06/2006</td>
</tr>
<tr>
<td>US 4677978 A</td>
<td>07/07/1987</td>
<td>US 04677978 A</td>
<td>07/07/1987</td>
</tr>
<tr>
<td>US 2012-0145147 Al</td>
<td>14/06/2012</td>
<td>CA 2652544 Al</td>
<td>13/12/2007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN 101541365 A</td>
<td>23/09/2009</td>
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<td></td>
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<td>EP 2023987 A2</td>
<td>18/02/2009</td>
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<tr>
<td></td>
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<td>EP 2023987 A4</td>
<td>26/06/2013</td>
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<tr>
<td>JP 2009-537234 A</td>
<td>29/10/2009</td>
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