A TUBE CONNECTOR FOR A LARGE-BORE CHEST TUBE, A TUBE CONNECTOR SYSTEM FOR AUGMENTING A CHEST TUBE DRAINAGE SYSTEM, AND A METHOD OF AUGMENTING A CHEST TUBE DRAINAGE SYSTEM

TECHNICAL FIELD

The present disclosure relates broadly to a tube connector for a large-bore chest tube, a tube connector system for augmenting a chest tube drainage system, and a method of augmenting a chest tube drainage system.

BACKGROUND

The intrapleural space is a space between the parietal pleura and the visceral pleura in a human chest cavity. Normally, the intrapleural space has a small amount of fluid within it in a healthy individual. This fluid is drained and regulated by the lymphatic system and provides lubrication and cohesion between the pleura for normal lung function. Due to a number of pathologic conditions, an individual may accumulate air, fluid, or purulent drainage in the intrapleural space. Chest tubes may be required to provide drainage of air and excess fluid of any type.

Currently, the use of small-bore chest tube (e.g., chest tube having a size of 14 French (Fr) or less) is more prevalent. The increase in use of small-bore chest tubes has left a void in advancements to large-bore chest tube care. However, the use of large-bore chest tube (e.g., chest tube having a size of more than 14 Fr) remains highly relevant in clinical practice. The relevance of large-bore chest tube is further supported by an increased use of intrapleural therapy, e.g., intrapleural enzyme therapy and autologous blood patch pleurodesis, where

the need to administer treatment via both small-bore and large-bore chest tubes in a safe and effective manner is essential.

Existing large-bore chest tubes do not come with a standardized connecting device. At present, large bore chest tubes are directly connected to an underwater seal tubing upon insertion, resulting in a closed system with no means to obtain further sampling of specimens should the need arise.

Best attempts to create a setup enabling specimen collection or intrapleural administration of medication via large bore chest tubes involve cumbersome connecting means and dressings. Inexperienced nurses or clinicians may be unfamiliar, and certain wards may not be readily stocked with the necessary components to assemble such cumbersome setups. This may result in variations in, and ultimately suboptimal chest tube care. Additionally, each linkage/ separate component may serve as potential nidus for infections, compromising patient care. Furthermore, there may be additional risks of dislodgement with each additional linkage/ tube connected to the existing setup. Other attempts to obtain samples may even involve breaching the underwater seal tubing with a needle and syringe to aspirate fluid.

Thus, there is a need for a tube connector for a large-bore chest tube, a tube connector system for augmenting a chest tube drainage system, and a method of augmenting a chest tube drainage system, which seek to address or at least ameliorate one of the above problems.

SUMMARY

In one aspect, there is provided a tube connector for a large-bore chest tube, the tube connector comprising a first connector portion having a first opening at a first end of the tube connector; a second connector portion having a second opening at a second end of the tube connector; and a lumen extending between the first and second openings, said lumen being configured to allow fluid

communication between the first and second openings; wherein the first connector portion comprises an exterior that is tapered towards the first end and is configured to facilitate a first coupling between the first connector portion and a distal end of the large-bore chest tube; and wherein the second connector portion comprises a locking member configured to facilitate a second coupling between the second connector portion and a mating connector.

In one embodiment of the tube connector as disclosed herein, the first connector portion comprises a plurality of tapered sections, each tapered section having a first diameter at a first end thereof that tapers to a smaller second diameter at a second end thereof, towards the first end of the tube connector.

In one embodiment of the tube connector as disclosed herein, the second diameter of a first tapered section is smaller than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

In one embodiment of the tube connector as disclosed herein, the first diameter of a first tapered section is larger than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

In one embodiment of the tube connector as disclosed herein, each of the plurality of tapered sections has substantially the same length.

In one embodiment of the tube connector as disclosed herein, a tapered section at the first end of the tube connector has a smaller taper angle relative to the tapered sections disposed further away from the first end of the tube connector.

In one embodiment of the tube connector as disclosed herein, the plurality of tapered sections have a maximum diameter and a minimum diameter dimensioned to facilitate coupling to a large-bore chest tube having a size ranging from no less than 14 Fr to no more than 40 Fr.

In one embodiment of the tube connector as disclosed herein, the lumen is substantially linear and has an inner diameter which is smaller at the first end of the tube connector as compared to the second end of the tube connector.

In one embodiment of the tube connector as disclosed herein, the locking member of the second connector portion comprises a coupling mechanism selected from luer lock, screw thread, snap-fit, or press/friction fit.

In one embodiment of the tube connector as disclosed herein, the tube connector is formed as a single piece.

In one aspect, there is provided a tube connector system for augmenting a chest tube drainage system, the system comprising a tube connector for a large-bore chest tube, said tube connector comprising a first connector portion having a first opening at a first end of the tube connector, wherein the first connector portion comprises an exterior that is tapered towards the first end and is configured to facilitate a first coupling between the first connector portion and a distal end of the large-bore chest tube; a second connector portion having a second opening at a second end, wherein the second connector portion comprises a locking member configured to facilitate a second coupling between the second connector portion and a mating connector; and a lumen extending between the first and second openings, said lumen being configured to allow fluid communication between the first and second openings; and a multi-way tap for providing access to the chest tube drainage system, said multi-way tap comprising a first port having a first mating connector configured to be coupled to the locking member of the second connector portion; a second port having a second mating connector configured to be coupled to a tubing of an underwater seal drainage unit; and at least one access port configured to facilitate introduction and/or removal of substance in relation to the chest tube drainage system.

In one embodiment of the system as disclosed herein, the first connector portion comprises a plurality of tapered sections, each tapered section having a first diameter at a first end thereof that tapers to a smaller second diameter at a second end thereof, towards the first end of the tube connector.

In one embodiment of the system as disclosed herein, the second diameter of a first tapered section is smaller than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

In one embodiment of the system as disclosed herein, the first diameter of a first tapered section is larger than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

In one embodiment of the system as disclosed herein, each of the plurality of tapered sections has substantially the same length.

In one embodiment of the system as disclosed herein, a tapered section at the first end of the tube connector has a smaller taper angle relative to the tapered sections disposed further away from the first end of the tube connector.

In one embodiment of the system as disclosed herein, the plurality of tapered sections have a maximum diameter and a minimum diameter dimensioned to facilitate coupling to a large-bore chest tube having a size ranging from no less than 14 Fr to no more than 40 Fr.

In one embodiment of the system as disclosed herein, the lumen is substantially linear and has an inner diameter which is smaller at the first end of the tube connector as compared to the second end of the tube connector.

In one aspect, there is provided a method of augmenting a chest tube drainage system, the method comprising coupling a first connector portion of a tube connector having a first opening at a first end of the tube connector and an

exterior that is tapered towards the first end, to a distal end of a large-bore chest tube; coupling a second connector portion of the tube connector having a second opening at a second end and a locking member, such that the locking member is coupled to a first mating connector of a multi-way tap; coupling a second mating connector of the multi-way tap to a tubing of an underwater seal drainage unit.

In one embodiment, the method further comprises introducing fluid into the chest tube drainage system and/or extracting a sample volume of fluid from the chest tube drainage system via at least one access port on the multi-way tap.

DEFINITIONS

The term “large-bore chest tube” as used herein broadly refers to a chest tube having an outer diameter which is more than about 14 Fr.

The term “small-bore chest tube” as used herein broadly refers to a chest tube having an outer diameter which is about 14 Fr or less.

The term “truncated cone” or “conical frustum” as used herein broadly refers to a cone with the apex cut off. In a truncated cone, the cutting plane is parallel to the base of the cone, or, equivalently, perpendicular to the normal of the base.

The term “biocompatible” as used herein is to be interpreted broadly to refer to the ability of an object, e.g., chest tube, chest tube connector, to perform its intended function without substantially producing any undesirable local or systemic effects in a subject receiving the object.

The term “bioinert” as used herein is to be interpreted broadly to refer to a material that does not substantially elicit an immune response from a human or animal when it is disposed within or comes into contact with an *in-vivo* biological environment.

The terms “proximal” and “distal” as defined herein are terms used to describe a location/position relative to a point of origin or a defined reference point. The term “distal” is defined as any point farther from the point of origin or other reference point than a “proximal” point. The term “proximal” is defined as any point closer to the point of origin or other reference point than a “distal” point. For example, the body of a subject, e.g., patient, or the location where a chest tube is inserted into the body of a subject may act as a point of origin or defined reference point.

The term “micro” as used herein is to be interpreted broadly to include dimensions from about 1 micron to about 1000 microns.

The term “nano” as used herein is to be interpreted broadly to include dimensions less than about 1000 nm.

The term “particle” as used herein broadly refers to a discrete entity or a discrete body. The particle described herein can include an organic, an inorganic or a biological particle. The particle used described herein may also be a macro-particle that is formed by an aggregate of a plurality of sub-particles or a fragment of a small object. The particle of the present disclosure may be spherical, substantially spherical, or non-spherical, such as irregularly shaped particles or ellipsoidally shaped particles. The term “size” when used to refer to the particle broadly refers to the largest dimension of the particle. For example, when the particle is substantially spherical, the term “size” can refer to the diameter of the particle; or when the particle is substantially non-spherical, the term “size” can refer to the largest length of the particle.

The terms “coupled” or "connected" as used in this description are intended to cover both directly connected or connected through one or more intermediate means, unless otherwise stated.

The term “associated with”, used herein when referring to two elements refers to a broad relationship between the two elements. The relationship includes, but is not limited to a physical, a chemical or a biological relationship. For example, when element A is associated with element B, elements A and B may be directly or indirectly attached to each other or element A may contain element B or vice versa.

The term “adjacent” used herein when referring to two elements refers to one element being in close proximity to another element and may be but is not limited to the elements contacting each other or may further include the elements being separated by one or more further elements disposed therebetween.

The term “and/or”, e.g., “X and/or Y” is understood to mean either “X and Y” or “X or Y” and should be taken to provide explicit support for both meanings or for either meaning.

Further, in the description herein, the word “substantially” whenever used is understood to include, but not restricted to, “entirely” or “completely” and the like. In addition, terms such as “comprising”, “comprise”, and the like whenever used, are intended to be non-restricting descriptive language in that they broadly include elements/components recited after such terms, in addition to other components not explicitly recited. For example, when “comprising” is used, reference to a “one” feature is also intended to be a reference to “at least one” of that feature. Terms such as “consisting”, “consist”, and the like, may in the appropriate context, be considered as a subset of terms such as “comprising”, “comprise”, and the like. Therefore, in embodiments disclosed herein using the terms such as “comprising”, “comprise”, and the like, it will be appreciated that these embodiments provide teaching for corresponding embodiments using terms such as “consisting”, “consist”, and the like. Further, terms such as “about”, “approximately” and the like whenever used, typically means a reasonable variation, for example a variation of +/- 5% of the disclosed value, or a variance

of 4% of the disclosed value, or a variance of 3% of the disclosed value, a variance of 2% of the disclosed value or a variance of 1% of the disclosed value.

Furthermore, in the description herein, certain values may be disclosed in a range. The values showing the end points of a range are intended to illustrate a preferred range. Whenever a range has been described, it is intended that the range covers and teaches all possible sub-ranges as well as individual numerical values within that range. That is, the end points of a range should not be interpreted as inflexible limitations. For example, a description of a range of 1% to 5% is intended to have specifically disclosed sub-ranges 1% to 2%, 1% to 3%, 1% to 4%, 2% to 3% etc., as well as individually, values within that range such as 1%, 2%, 3%, 4% and 5%. It is to be appreciated that the individual numerical values within the range also include integers, fractions and decimals. Furthermore, whenever a range has been described, it is also intended that the range covers and teaches values of up to 2 additional decimal places or significant figures (where appropriate) from the shown numerical end points. For example, a description of a range of 1% to 5% is intended to have specifically disclosed the ranges 1.00% to 5.00% and also 1.0% to 5.0% and all their intermediate values (such as 1.01%, 1.02% … 4.98%, 4.99%, 5.00% and 1.1%, 1.2% ... 4.8%, 4.9%, 5.0% etc.,) spanning the ranges. The intention of the above specific disclosure is applicable to any depth/breadth of a range.

Additionally, when describing some embodiments, the disclosure may have disclosed a method and/or process as a particular sequence of steps. However, unless otherwise required, it will be appreciated that the method or process should not be limited to the particular sequence of steps disclosed. Other sequences of steps may be possible. The particular order of the steps disclosed herein should not be construed as undue limitations. Unless otherwise required, a method and/or process disclosed herein should not be limited to the steps being carried out in the order written. The sequence of steps may be varied and still remain within the scope of the disclosure.

Furthermore, it will be appreciated that while the present disclosure provides embodiments having one or more of the features/characteristics discussed herein, one or more of these features/characteristics may also be disclaimed in other alternative embodiments and the present disclosure provides support for such disclaimers and these associated alternative embodiments.

DESCRIPTION OF EMBODIMENTS

Exemplary, non-limiting embodiments of a tube connector for a large-bore chest tube, a tube connector system for augmenting a chest tube drainage system, and a method of augmenting a chest tube drainage system are disclosed hereinafter.

TUBE CONNECTOR FOR A LARGE-BORE CHEST TUBE

In various embodiments, there is provided a tube connector for a large-bore chest tube, the tube connector comprising a first connector portion having a first opening at a first end of the tube connector; a second connector portion having a second opening at a second end of the tube connector; and a lumen extending between the first and second openings, said lumen being configured to allow fluid communication between the first and second openings; wherein the first connector portion comprises an exterior that is tapered towards the first end and is configured to facilitate a first coupling between the first connector portion and a distal end of the large-bore chest tube; and wherein the second connector portion comprises a locking member configured to facilitate a second coupling between the second connector portion and a mating connector. In various embodiments, the tube connector is a chest tube connector. In various embodiments, the tube connector is a large-bore chest tube connector.

In various embodiments, the tube connector is configured to be deployed in a chest tube drainage setup. The chest tube drainage setup may comprise a chest tube, e.g., large-bore chest tube and an underwater seal drainage unit. The

large-bore chest tube may be in the form of a flexible tubing comprising a proximal end configured to be inserted in the pleural space of a subject for removing air and fluid, e.g., pleural effusion therefrom, and a distal end configured to be coupled to an underwater seal drainage unit. The underwater seal drainage unit may comprise a drainage container, e.g., drainage bottle, configured to collect fluid and a drainage tube configured to direct air and fluid to the drainage container. The drainage tube may comprise a proximal end configured to be coupled to the distal end of the large-bore chest tube and a distal end configured to be submerged in water in the drainage container. In various embodiments, the tube connector is configured to be compatible with existing large-bore chest tubes known in the art. This may advantageously provide ease of integration of the tube connector with existing chest tube and drainage tube products.

In various embodiments, the tube connector is configured to be deployed/positioned between the large-bore chest tube and the underwater seal drainage unit. In various embodiments, the tube connector is configured to be coupled between the distal end of the large-bore chest tube and the proximal end of the drainage tube. For example, the tube connector may be indirectly connected to the proximal end of the drainage tube. The second connector portion of the tube connector may be configured to be coupled to a first port of a multi-way tap, and a second port of the multi-way tap may be configured to be coupled to a separate connector, e.g., a drainage tube connector, said separate connector being configured to be coupled to the proximal end of the drainage tube. In various embodiments, the tube connector may advantageously provide a link way for separate attachment of additional/intermediate components such as a multi-way tap, e.g., 3-way tap, separate connectors, and syringes for the purpose of routine management of a patient with a chest tube. In various embodiments, the tube connector may be configured to be coupled to a multi-way tap via the locking member at the second connector portion. In various embodiments therefore, the tube connector may facilitate areas of care including aspirating pleural fluid for sampling purposes, flushing of the chest tube to ensure patency, as well as administering intra-pleural medication (e.g., Talc slurry,

intrapleural enzyme therapy). Advantageously, these areas of care may be performed without the need to disconnect the chest tube from the underwater seal drainage unit, thereby preserving the integrity and sterility of the chest tube drainage setup.

In various embodiments, the tube connector may take the form of a hollow elongate member. In various embodiments, the tube connector may have a length of from about 30 mm to about 100 mm. In various embodiments, the tube connector may have a length falling in a range with start and end points selected from the following group of numbers: 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, and 100 mm.

In various embodiments, the tube connector may have an external diameter ranging from about 1 mm to about 20 mm. In various embodiments, the external diameter of the tube connector may not be uniform along the length thereof. In various embodiments, the tube connector may have a maximum external diameter of about 20 mm at the widest section. In various embodiments, the tube connector may have a minimum external diameter of about 1 mm at the narrowest section. In various embodiments, the tube connector may have an external diameter falling in a range with start and end points selected from the following group of numbers: 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, 10, 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 10.9, 11, 11.1, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7, 11.8, 11.9, 12, 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 12.9, 13, 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, 13.7, 13.8, 13.9, 14, 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7, 14.8, 14.9, 15, 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, 15.9, 16, 16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8, 16.9, 17, 17.1, 17.2, 17.3, 17.4, 17.5, 17.6, 17.7, 17.8, 17.9, 18, 18.1, 18.2, 18.3, 18.4, 18.5,

18.6, 18.7, 18.8, 18.9, 19, 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8, 19.9, and 20 mm.

In various embodiments, the first connector portion of the tube connector is configured to be removably coupled to the distal end of the large-bore chest tube. In various embodiments, the first connector portion comprises an exterior/external profile that is tapered towards the first end. In various embodiments, the exterior/external profile of the first connector portion may take the form of a truncated conical shape. In various embodiments, the tapered exterior and the truncated conical shape of the first connector portion may be complementary to a funnelled design/ funnel shape at the distal end of the large-bore chest tube, thereby advantageously creating a simple-to-apply and tight seal, e.g., air-tight and/or water-tight seal.

In various embodiments, the first connector portion may comprise a plurality of ridges formed on the tapered exterior, e.g., truncated conical exterior thereof. In various embodiments, the plurality of ridges are formed along a circumference of a lateral surface of the truncated conical exterior. In various embodiments, the plurality of ridges may be a plurality of circular ridges. In various embodiments, the circular ridges are concentric circular ridges, such that the centres of the circular ridges coincide with a longitudinal axis of the first connector portion. In various embodiments, the circular ridges are spaced apart at regular intervals along the truncated conical exterior of the first connector portion. In various embodiments, due to the tapered exterior of the first connector portion, the circular ridge that is furthest away from the first end of the tube connector has the largest diameter. In various embodiments, due to the tapered exterior of the first connector portion, the circular ridges that is nearest to the first end of the tube connector has the smallest diameter. In various embodiments, the diameters of the plurality of circular ridges decrease towards the first end of the tube connector. In various embodiments, the plurality of ridges may advantageously ensure a secure connection with the first connector portion over different chest tube sizes.

In various embodiments, the first connector portion may comprise a plurality of tapered sections. In various embodiments, the tapered section may take the form of a truncated cone. In various embodiments, the tapered section may have a first diameter at a first end thereof that tapers to a smaller second diameter at a second end thereof, towards the first end of the tube connector. In various embodiments, the first end of each tapered section is further away from the first end of the tube connector as compared to the second end of each tapered section. In various embodiments, the second diameter of a first tapered section is smaller than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section. In various embodiments, the first diameter of a first tapered section is larger than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section. In various embodiments therefore, the plurality of tapered sections forms the exterior/external profile of the first connector portion that is tapered towards the first end of the tube connector. In various embodiments, the first end of each tapered section forms a circular ridge on the exterior of the first connector portion.

In various embodiments, the configuration of the circular ridges on the first connector portion as described above may facilitate unidirectional insertion of the chest tube and substantially resist decoupling/removal once the chest tube is inserted. Advantageously, the combination of the exterior/external profile of the first connector portion that is tapered towards the first end and the presence of ridges formed on the exterior of the first connector portion may provide a simple-to-apply and secure connection with the first connector portion over different chest tube sizes. This would lead to safer patient care, with less risk of dislodgement of the various components of the tube connector.

In various embodiments, the first connector portion is dimensioned to facilitate coupling to a large-bore chest tube having a size ranging from no less than 14 Fr to no more than 40 Fr. In various embodiments, the plurality of tapered sections have a minimum external diameter and a maximum external diameter

dimensioned to facilitate coupling to a large-bore chest tube having a size ranging from no less than 14 Fr to no more than 40 Fr. In various embodiments, the first connector portion of the tube connector is configured to couple to a large-bore chest tube having a size falling in a range with start and end points selected from the following group of numbers: 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, and 40 Fr. In various embodiments, the truncated cone shape of the first connector portion is configured to complement the distal end of the large-bore chest tube which may terminate in a funnel design/shape. In various embodiments, the first connector portion having a designated minimum external diameter and a designated maximum external diameter is advantageously capable of fitting into the funnel design across a variety of chest tube sizes.

In various embodiments, each of the plurality of tapered sections may have substantially the same length. In various embodiments, each of the plurality of tapered sections may have different lengths. In various embodiments, the length of the tapered section may be from about 3 mm to about 10 mm. In various embodiments, the length of the tapered section may fall in a range with start and end points selected from the following group of numbers: 3, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, and 10 mm.

In various embodiments, the plurality of tapered sections may have a taper angle from about 4° to about 10°. In various embodiments, the plurality of tapered sections may have a taper angle falling in a range with start and end points selected from the following group of numbers: 4, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, and 10°. In various embodiments, a tapered section at the first end of the tube connector may have

a smaller taper angle relative to the tapered sections disposed further away from the first end of the tube connector. In various embodiments, the taper angle may be optimised by performing mechanical pull testing to assess the performance of a particular taper angle against a standard or reference taper angle.

In various embodiments, the locking member of the second connector portion of the tube connector is configured to be removably coupled to the mating connector. In various embodiments, the locking member of the second connector portion of the tube connector is configured to form a tight seal, e.g., air-tight and/or water-tight seal with the mating connector. In various embodiments, the mating connector may be part of a multi-way tap or syringe. In various embodiments, the locking member of the second connector portion comprises a coupling mechanism selected from luer lock, screw thread, snap-fit, or press/friction fit. For example, the locking member may be a female luer lock configured to couple to a male luer lock on a multi-way tap, or vice versa.

In various embodiments, the lumen is configured to allow fluid communication between the first and second openings of the tube connector. In various embodiments, the lumen is substantially linear. In various embodiments, the lumen has an inner diameter which is smaller at the first end of the tube connector as compared to the second end of the tube connector. In various embodiments, the substantially linear lumen advantageously minimizes the amount of dead space within the tube connector which may otherwise be present in a tube connection setup with multiple angular turns and junctions. This may advantageously reduce the likelihood of clogging and the risk of infection, the dead space may serve as potential nidus for microbes, compromising patient care. In various embodiments, the surface of the lumen may be physically and/or chemically treated to minimize clogging and/or growth of microbes.

In various embodiments, the lumen may have an internal diameter ranging from about 2 mm to about 10 mm. In various embodiments, the lumen may have an internal diameter falling in a range with start and end points selected from the

following group of numbers: 2, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 6, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, and 10 mm.

In various embodiments, the tube connector may be substantially transparent to light. This may advantageously facilitate monitoring of the tube connector for clogging. In various embodiments, the tube connector may be substantially rigid, i.e., not flexible. This advantageously prevent kinking which may happen in a flexible/pliable tube connector. In various embodiments, the tube connector is formed as a single piece. This advantageously minimizes leakage of fluid which may happen in a tube connector assembled from multiple parts.

In various embodiments, the tube connector may be made of medical grade material. In various embodiments, the tube connector may be made of plastic or metal. In various embodiments, suitable plastic materials for making the tube material may include but are not limited to Biomed clear resin, nylon, polyurethane, polyvinylidene fluoride (PVDF), polyaryletheretherketone (PEEK), polytetrafluoroethylene (PTFE), Teflon™ (various fluoropolymers), poly(vinyl chloride) (PVC), or combinations thereof. In various embodiments, the tube connector may be fabricated using techniques such as stereolithography, additive manufacturing, 3D-printing, injection molding, and extrusion.

In various embodiments, the tube connector may be configured for single use. For example, at low volume production via 3D printing, the base cost of a tube connector is approximately S$6, excluding sterilising/ packaging. At high volume production, the base cost of fabricating a tube connector is expected to be even lower due to economies of scale. Accordingly, the relative low cost of production enables the tube connector to be configured for single use.

In various embodiments, the tube connector is biocompatible, bioinert, and sterilisable. In various embodiments, parts of the tube connector that come into contact (directly or indirectly) with the chest tube is/are biocompatible, bioinert, and sterilisable. In various embodiments, the whole tube connector is biocompatible, bioinert, and sterilisable. Sterilisation may be performed using suitable materials and techniques known in the art, e.g., ethylene oxide, gamma or electron beam irradiation, plasma, or autoclave sterilization. Accordingly, the tube connector is made of materials that are able to withstand the desired sterilization methods without substantial or appreciable loss in its desired properties or functions.

TUBE CONNECTOR SYSTEM FOR AUGMENTING A CHEST TUBE DRAINAGE SYSTEM

In various embodiments, there is provided a tube connector system for augmenting a chest tube drainage system, the system comprising a tube connector for a large-bore chest tube, said tube connector comprising a first connector portion having a first opening at a first end of the tube connector, wherein the first connector portion comprises an exterior that is tapered towards the first end and is configured to facilitate a first coupling between the first connector portion and a distal end of the large-bore chest tube; a second connector portion having a second opening at a second end, wherein the second connector portion comprises a locking member configured to facilitate a second coupling between the second connector portion and a mating connector; and a lumen extending between the first and second openings, said lumen being configured to allow fluid communication between the first and second openings; and a multi-way tap for providing access to the chest tube drainage system, said multi-way tap comprising a first inlet port having a first mating connector configured to be coupled to the locking member of the second connector portion; a second outlet port having a second mating connector configured to be coupled to a tubing of an underwater seal drainage unit; and at least one access port

configured to facilitate introduction and/or removal of substance in relation to the chest tube drainage system.

In various embodiments, the tube connector system is configured to be deployed in a chest tube drainage system. The chest tube drainage system may comprise a chest tube, e.g., large-bore chest tube and an underwater seal drainage unit. The large-bore chest tube may be in the form of a flexible tubing comprising a proximal end configured to be inserted in the pleural space of a subject for removing air and fluid, e.g., pleural effusion therefrom, and a distal end configured to be coupled to the first connector portion of the tube connector. The underwater seal drainage unit may comprise a drainage container, e.g., drainage bottle, configured to collect fluid and a drainage tube configured to direct air and fluid to the drainage container. The drainage tube may comprise a proximal end configured to be coupled to the second mating connector of the multi-way tap and a distal end configured to be submerged in water in the drainage container. The proximal end of the drainage tube may be indirectly connected to the second mating connector of the multi-way tap via a drainage tube connector. In various embodiments, the tube connector is configured to be compatible with existing large-bore chest tubes and drainage tubes known in the art. This may advantageously provide ease of integration of the tube connector with existing chest tube and drainage tube products.

In various embodiments, the multi-way tap comprises valves and a handle for setting the valves for different configurations of flow. In various embodiments, the multi-way tap may include but is not limited to a 3-way tap or 4-way tap. For example, a 3-way tap comprises a 3-way valve and a handle that switches the 3-way tap in different configurations of flow. In various embodiments, the multi-way tap, e.g., 3-way tap or 4-way tap, may be a standardized multi-way tap commercially available in the art.

In various embodiments, the tube connector and multi-way tap may be left in place in connection with the large-bore chest and underwater seal drainage

unit after assembly. In various embodiments, the multi-way tap may be set in a first configuration to allow pleural effusion and/or air to flow/drain from the pleural cavity directly into the underwater seal drainage unit. In various embodiments, the multi-way tap may be set in a second configuration to allow fluid or medication to be administered via the access port of the multi-way tap through the tube connector directly into the large-bore chest tube, without the need to pass through additional linkages or tubing. In various embodiments, the second configuration may allow extraction of a sample volume of fluid (i.e., liquid and/or gas, e.g., air) from the chest tube drainage system, without the need to pass through additional linkages or tubing.

METHOD OF AUGMENTING A CHEST TUBE DRAINAGE SYSTEM

In various embodiments, there is provided a method of augmenting a chest tube drainage system, the method comprising coupling a first connector portion of a tube connector having a first opening at a first end of the tube connector and an exterior that is tapered towards the first end, to a distal end of a large-bore chest tube; coupling a second connector portion of the tube connector having a second opening at a second end and a locking member, such that the locking member is coupled to a first mating connector of a multi-way tap; and coupling a second mating connector of the multi-way tap to a tubing of an underwater seal drainage unit.

In various embodiments, the method further comprises introducing fluid into the chest tube drainage system and/or extracting a sample volume of fluid (i.e., liquid and/or gas, e.g., air) from the chest tube drainage system via at least one access port on the multi-way tap. This advantageously enables an operator, e.g., healthcare professional to perform aspiration of pleural fluid for sampling purposes, flushing of the chest tube to ensure patency, as well as administering intra-pleural medication (e.g., Talc slurry, intrapleural enzyme therapy), without having to disconnect the chest tube from the underwater seal, thereby preserving the integrity and sterility of the chest tube drainage system.

BRIEF DESCRIPTION OF FIGURES

FIG. 1A is a schematic perspective view drawing of a tube connector for a large-bore chest tube in an example embodiment.

FIG. 1B is a schematic side view drawing of the tube connector in the example embodiment.

FIG. 2 is a photograph of a tube connector for a large-bore chest tube in an example embodiment.

FIG. 3A is a schematic top view drawing of a chest tube connector system for augmenting a chest tube drainage system in an example embodiment.

FIG. 3B is a photograph showing an assembled chest tube connector system for augmenting a chest tube drainage system in the example embodiment.

FIG. 4 is a photograph showing a closed system chest tube drainage formed by a large-bore chest tube and an underwater seal drainage that is currently practiced in the state of the art.

FIG. 5A is a photograph showing an assortment of tube connectors and multi-way taps for connecting to a large-bore chest tube that is currently practiced in the prior art.

FIG. 5B is a first photograph showing an assembly of tube connectors and multi-way taps connected to a large-bore chest tube that is currently practiced in the prior art.

FIG. 5C is a second photograph showing an assembly of tube connectors and multi-way taps connected to a large-bore chest tube that is currently practiced in the prior art.

DETAILED DESCRIPTION OF FIGURES

Example embodiments of the disclosure will be better understood and readily apparent to one of ordinary skill in the art from the following discussions and if applicable, in conjunction with the figures. It should be appreciated that other modifications related to structural, and material changes may be made without deviating from the scope of the invention. Example embodiments are not necessarily mutually exclusive as some may be combined with one or more embodiments to form new exemplary embodiments. The example embodiments should not be construed as limiting the scope of the disclosure.

FIG. 1A and 1B show 3D digital Computer Aided Design (CAD) model of a tube connector, e.g., chest tube connector 100 for a large-bore chest tube in an example embodiment. The dimensions of the various components of the chest tube connector 100 are shown in FIG. 1B.

The chest tube connector 100 comprises a first connector portion 102 having a first opening 104 at a first end of the chest tube connector 100. The first connector portion 102 comprises an exterior that is tapered towards the first end and is configured to facilitate a first coupling between the first connector portion 102 and a distal end of the large-bore chest tube. The chest tube connector 100 further comprises a second connector portion 106 having a second opening 108 at a second end of the chest tube connector 100. The second connector portion 106 comprises a locking member, e.g., female luer lock 110 configured to facilitate a second coupling between the second connector portion 106 and a mating connector, e.g., mating connector of a multi-way tap. The large-bore chest tube connector 100 further comprises a lumen 112 (see pair of dotted lines) extending between the first opening 104 and second opening 108, said lumen

being configured to allow fluid communication between the first opening 104 and second opening 108.

The first connector portion 102 comprises a plurality of tapered sections, e.g., truncated cones 114, 116 etc. Each truncated cone has a height of about 4 mm. Each truncated cone has a first (major) diameter at a first end thereof that tapers to a smaller second (minor) diameter at a second end thereof, towards the first end of the chest tube connector 100. For example, the first end of the truncated cone 114 is further away from the first end of the chest tube connector 100 as compared to the second end of the truncated cone 114.

The second diameter of the truncated cone 114 is smaller than the first diameter of another truncated cone 116 disposed adjacent to the second end of the first truncated cone 114. The first diameter of the truncated cone 114 is larger than the first diameter of the truncated cone 116 disposed adjacent to the second end of the first truncated cone 114. The plurality of tapered sections forms the exterior/external profile of the first connector portion 102 that is tapered towards the first end of the chest tube connector 100. The first end of each truncated cone forms a ridge or step, e.g., circular ridge 118 on the exterior of the first connector portion 102.

The largest diameter of the first connector portion 102 is defined by the first (major) diameter of the truncated cone that is furthest away from the first end of the tube connector 100. The smallest diameter of the first connector portion 102 is defined by the second (minor) diameter of the truncated cone that is nearest to the first end of the chest tube connector 100. As shown in FIG. 1B, the largest diameter of the first connector portion 102 is about 13.20 mm and the narrowest diameter of the first connector portion 102 is about 7.80 mm. It will be appreciated that the distal end of a large-bore chest tube terminates in a funnel design that complements the truncated cone shape of the chest tube connector across a variety of chest tube sizes.

The plurality of truncated cones, e.g., 114, 116, have a taper angle of about 8.51°. The taper angle of the truncated cone nearest to the first end of the chest tube connector 100 has a smaller taper angle of 4.39° relative to the preceding truncated cones that are disposed further away from the first end of the chest tube connector 100.

The lumen 112 is configured to allow fluid communication between the first and second openings 104, 108 of the chest tube connector 100. For example, the lumen 112 allows fluid, e.g., medication to flow from the second end to the first end of the tube connector towards the pleural space of a subject. The lumen 112 also allows air/fluid to flow from the first end to the second end of the tube connector 100 towards an underwater seal drainage unit. The lumen 112 is substantially linear and has an inner diameter which is smaller at the first end of the tube connector as compared to the second end of the tube connector. As shown in FIG. 1B, the lumen 112 has a non-uniform inner diameter. At the first end of the tube connector 100, the lumen 112 has an inner diameter of about 4 mm. At the second end of the tube connector 100, the lumen has an inner diameter of about 5.88 mm.

The chest tube connector 100 is produced via stereolithography (SLA) 3D printing with Biomed Clear Resin. The chest tube connector 100 is 3D printed in a printer facility jointly within Tan Tock Seng Hospital (TTSH), licensed under the Private Hospitals and Medical Clinics (PHPC) Act. It is also recommended for the material to be printed by vendors that meet the certified ISO 13485:2016 Medical Devices QMS. The material used for the 3D printing is USP Class VI certified which ensures that that there are no harmful reactions or long-term bodily effects caused by chemicals that leach out of plastic materials. The chest tube connector 100 is also compatible with common sterilization methods. After the chest tube connector 100 is fabricated, a basic bubble test may be set up to check for leakages therefrom.

In the example embodiment, the chest tube connector 100 has tapered steps on its conical end, complementing the funnelled design typically found at the end of a large-bore chest tube to create a simple-to-apply and tight seal. The circular ridges 118 have different diameters along the exterior of the first connector portion 102, thereby ensuring a secured connection over different chest tube sizes. On its other end, the locking member 110 at the second connector portion 106 comprises screw thread configuration to allow for the attachment of a standardized 3-way tap in a twist-to-lock mechanism. Upon attachment, the chest tube connector 100 and 3-way tap may be left in its place, allowing pleural effusion or air to drain from the pleural cavity directly into the underwater seal drainage unit. Fluids/ medication administered via the 3-way tap pass through the chest tube connector 100 directly into the chest tube, without the need to pass through additional linkages/ tubing.

FIG. 2 is a photograph of a tube connector, e.g., chest tube connector 200 for a large-bore chest tube in an example embodiment. The large-bore chest tube connector 200 was fabricated according to the CAD model shown in FIG. 1A and 1B.

FIG. 3A is a schematic top view drawing of a chest tube connector system 300 for augmenting a chest tube drainage system in an example embodiment. The chest tube connector system 300 comprises a chest tube connector 302 for a large-bore chest tube, a drainage tube connector 304, and a multi-way tap, e.g., 3-way tap 306. The chest tube connector 302 is substantially similar to the chest tube connector 100 of FIG. 1A and 1B. For avoidance of doubt, the drainage tube connector 304 is not the chest tube connector 302.

The chest tube connector 302 comprises a first connector portion 308 (also compare 102 of FIG. 1B) having an exterior that is tapered and is configured to facilitate a first coupling between the first connector portion 308 and a distal end of the large-bore chest tube. The chest tube connector 302 further comprises a second connector portion 310 (also compare 106 of FIG. 1B). The second

connector portion 310 comprises a locking member, e.g., female luer lock 312 (also compare 110 of FIG. 1B) configured to facilitate a second coupling between the second connector portion 310 and a mating connector of the multi-way tap 306.

The multi-way tap, e.g., 3-way tap 306 comprises a first inlet port 314 having a first mating connector, e.g., male luer lock 316 configured to be coupled to the female luer lock 312 of the second connector portion 310; a second outlet port 318 having a second mating connector 320 configured to be coupled to the drainage tube connector 304, which in turn is configured to be coupled to a drainage tube of an underwater seal drainage unit; and an access port 322 configured to facilitate introduction and/or removal of substance in relation to the chest tube drainage system. The drainage tube connector 304 is a standard connector that is readily available in existing chest tube packages. The drainage tube connector 304 is configured to be connected to the 3-way tap 306 so that it can be connected to the drainage tube of the underwater seal drainage unit.

In the example embodiment, the chest tube connectors 302 may be inserted between the connection of the large bore chest tube and the underwater seal drainage unit, providing a link way for the addition of a multi-way tap, e.g., 3-way tap 306. That is, the chest tube connector 302 is configured to be fitted between the distal end of the large-bore chest tube and the 3-way tap 306, and the drainage tube connector 304 is configured to be fitted between the 3-way tap 306 and the drainage tube of the underwater seal drainage unit.

FIG. 3B is a photograph showing an assembled chest tube connector system 300 for augmenting a chest tube drainage system in the example embodiment. As shown, the chest tube connector 302 and 3-way tap 306 are assembled with a large-bore chest tube 324 and a drainage tube 326 of the underwater seal drainage unit. Upon assembly, the chest tube connector 302 and 3-way tap 306 may be left in its place, allowing pleural effusion or air to drain from the pleural cavity directly into the drainage tube 326 of the underwater seal

drainage unit. Fluids or medication administered via the 3-way tap 306 passes through the chest tube connector 302 directly into the large-bore chest tube 324, without the need to pass through additional linkages/ tubing. This setup advantageously enables the separate attachment of the 3-way tap 306 and syringes for the purpose of routine management of a patient with a chest tube. This setup advantageously enables an operator, e.g., healthcare professional to perform areas of care include aspirating pleural fluid for sampling purposes, flushing of the chest tube to ensure patency, as well as administering intra-pleural medication (e.g., Talc slurry, intrapleural enzyme therapy). These areas of care may be performed without the need to disconnect the large-bore chest tube 324 from the underwater seal drainage unit, thereby preserving the integrity and sterility of the system 300.

Various embodiments of the chest tube connector, chest tube connector system and its associated method as disclosed herein may overcome current limitations faced in the state of the art which are described with reference to FIG. 4 and FIG. 5A to 5C.

At present, large bore chest tubes are directly connected to an underwater seal upon insertion, thereby forming a closed system. FIG. 4 is a photograph showing a closed system chest tube drainage formed by a large-bore chest tube and an underwater seal drainage that is currently practiced in the state of the art. The closed system impedes an operator, e.g., healthcare professional, from obtaining further sampling of specimens, e.g., pleural effusion, should the need arise

Best attempts to create a setup enabling specimen collection or intrapleural administration of medication via large bore chest tubes involve cumbersome connecting means and dressings. FIG. 5A is a photograph showing an assortment of tube connectors 500 and multi-way taps 502 for connecting to a large-bore chest tube that is currently practiced in the prior art. FIG. 5B is a first photograph showing an assembly of tube connectors 500 and multi-way taps 502

connected to a large-bore chest tube 504 and underwater seal drainage tube 506 that is currently practiced in the prior art. FIG. 5C is a second photograph showing an assembly of tube connectors 500 and multi-way taps 502 connected to a large-bore chest tube 504 that is currently practiced in the prior art.

Inexperienced nurses or clinicians may be unfamiliar with setups such as the one shown in FIG. 5A to 5C, and certain wards may not be readily stocked with the necessary components. This may result in variations in, and ultimately suboptimal chest tube care. Additionally, each linkage/ separate component may serve as potential nidus for infections, compromising patient care. Furthermore, there may be additional risks of dislodgement with each additional linkage/ tube connected to the existing setup. Other attempts to obtain samples may even involve breaching the underwater seal tubing with a needle and syringe to aspirate fluid.

The inventors have conducted an extensive search among potential vendors supplying connectors and chest tube accessories in Singapore, as well as correspondence with the major hospitals. However, there is no connector similar to embodiments of the tube connector disclosed herein, and there is also no other device that addresses the clinical problems faced by large-bore chest tubes.

Various embodiments described herein provide a chest tube connector having a tapered end with step/ridges on one side. It is this unique design of tapered steps on its conical end coupled with a locking member e.g., female luer on the opposite end that allows pleural effusion or air to drain from the pleural cavity directly into the underwater seal drainage unit. Various embodiments of the chest tube connector provide a simple device that will eliminate the need for non-standardized setups. This will reduce variations in practice on the ground, which in the absence of experience/ knowledge among clinicians/ nurses, may pose an obstacle in chest tube management. Various embodiments of the chest tube connector may also minimise the amount of dead space within the set-up (by

minimising use of linkages/ components) and therefore, may reduce the risk of infection. Patient care would also be safer, with less risk of dislodgement of the various components with mobilising/ nursing care.

APPLICATIONS

Embodiments of the disclosure provided herein provide a tube connector for a large-bore chest tube, a tube connector system for augmenting a chest tube drainage system, and a method of augmenting a chest tube drainage system.

Advantageously, embodiments of the tube connector offer a simplified, economical, and effective solution to manage patients on large-bore chest tubes. Embodiments of the tube connector require minimal expert knowledge to operate and has the potential to improve overall patient care. This results in a significant improvement to the current cumbersome and non-standardised technique of connecting large-bore chest tube to a 3-way valve.

Accordingly, embodiments of the tube connector may be used in various kinds of applications such as respiratory and critical care, intrapleural therapy and the like.

It will be appreciated by a person skilled in the art that other variations and/or modifications may be made to the embodiments disclosed herein without departing from the spirit or scope of the disclosure as broadly described. For example, in the description herein, features of different exemplary embodiments may be mixed, combined, interchanged, incorporated, adopted, modified, included etc. or the like across different exemplary embodiments. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A tube connector for a large-bore chest tube, the tube connector comprising

a first connector portion having a first opening at a first end of the tube connector;

a second connector portion having a second opening at a second end of the tube connector; and

a lumen extending between the first and second openings, said lumen being configured to allow fluid communication between the first and second openings;

wherein the first connector portion comprises an exterior that is tapered towards the first end and is configured to facilitate a first coupling between the first connector portion and a distal end of the large-bore chest tube; and

wherein the second connector portion comprises a locking member configured to facilitate a second coupling between the second connector portion and a mating connector.

2. The tube connector according to claim 1, wherein the first connector portion comprises a plurality of tapered sections, each tapered section having a first diameter at a first end thereof that tapers to a smaller second diameter at a second end thereof, towards the first end of the tube connector.

3. The tube connector according to claim 2, wherein the second diameter of a first tapered section is smaller than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

4. The tube connector according to claim 2, wherein the first diameter of a first tapered section is larger than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

5. The tube connector according to any one of claims 2 to 4, wherein each of the plurality of tapered sections has substantially the same length.

6. The tube connector according to any one of claims 2 to 5, wherein a tapered section at the first end of the tube connector has a smaller taper angle relative to the tapered sections disposed further away from the first end of the tube connector.

7. The tube connector according to any one of claims 2 to 6, wherein the plurality of tapered sections have a maximum diameter and a minimum diameter dimensioned to facilitate coupling to a large-bore chest tube having a size ranging from no less than 14 Fr to no more than 40 Fr.

8. The tube connector according to any one of claims 1 to 7, wherein the lumen is substantially linear and has an inner diameter which is smaller at the first end of the tube connector as compared to the second end of the tube connector.

9. The tube connector according to any one of claims 1 to 8, wherein the locking member of the second connector portion comprises a coupling mechanism selected from luer lock, screw thread, snap-fit, or press/friction fit.

10. The tube connector according to any one of claims 1 to 9, wherein the tube connector is formed as a single piece.

11. A tube connector system for augmenting a chest tube drainage system, the system comprising

a tube connector for a large-bore chest tube, said tube connector comprising

a first connector portion having a first opening at a first end of the tube connector, wherein the first connector portion comprises an exterior that is tapered towards the first end and is configured to facilitate a first

coupling between the first connector portion and a distal end of the large-bore chest tube;

a second connector portion having a second opening at a second end, wherein the second connector portion comprises a locking member configured to facilitate a second coupling between the second connector portion and a mating connector; and

a lumen extending between the first and second openings, said lumen being configured to allow fluid communication between the first and second openings; and

a multi-way tap for providing access to the chest tube drainage system, said multi-way tap comprising

a first port having a first mating connector configured to be coupled to the locking member of the second connector portion;

a second port having a second mating connector configured to be coupled to a tubing of an underwater seal drainage unit; and

at least one access port configured to facilitate introduction and/or removal of substance in relation to the chest tube drainage system.

12. The system according to claim 11, wherein the first connector portion comprises a plurality of tapered sections, each tapered section having a first diameter at a first end thereof that tapers to a smaller second diameter at a second end thereof, towards the first end of the tube connector.

13. The system according to claim 12, wherein the second diameter of a first tapered section is smaller than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

14. The system according to claim 12, wherein the first diameter of a first tapered section is larger than the first diameter of a second tapered section disposed adjacent to the second end of the first tapered section.

15. The system according to any one of claims 12 to 14, wherein each of the plurality of tapered sections has substantially the same length.

16. The system according to any one of claims 12 to 15, wherein a tapered section at the first end of the tube connector has a smaller taper angle relative to the tapered sections disposed further away from the first end of the tube connector.

17. The system according to any one of claims 12 to 16, wherein the plurality of tapered sections have a maximum diameter and a minimum diameter dimensioned to facilitate coupling to a large-bore chest tube having a size ranging from no less than 14 Fr to no more than 40 Fr.

18. The system according to any one of claims 11 to 17, wherein the lumen is substantially linear and has an inner diameter which is smaller at the first end of the tube connector as compared to the second end of the tube connector.

19. A method of augmenting a chest tube drainage system, the method comprising

coupling a first connector portion of a tube connector having a first opening at a first end of the tube connector and an exterior that is tapered towards the first end, to a distal end of a large-bore chest tube;

coupling a second connector portion of the tube connector having a second opening at a second end and a locking member, such that the locking member is coupled to a first mating connector of a multi-way tap; and

coupling a second mating connector of the multi-way tap to a tubing of an underwater seal drainage unit.

20. The method according to claim 19, further comprising introducing fluid into the chest tube drainage system and/or extracting a sample volume of

fluid from the chest tube drainage system via at least one access port on the multi-way tap.