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ROUSSEAU et al.(10) **Pub. No.: US 2009/0076526 A1**(43) **Pub. Date: Mar. 19, 2009**(54) **COMPRESSION, BANDING AND
PERCUTANEOUS AIRWAY LIGATION OF
EMPHYSEMATOUS LUNG TISSUE****Related U.S. Application Data**(60) Provisional application No. 60/973,269, filed on Sep.
18, 2007.(76) Inventors: **Alexandra ROUSSEAU**,
Cambridge, MA (US); **Mark
WOOD**, Shrewsbury, MA (US);
Jon T. McIntYRE, Newton, MA
(US); **Claude CLERC**,
Marlborough, MA (US); **Gary
LEANNA**, Holden, MA (US);
Michael S. H. CHU, Brookline,
MA (US)**Publication Classification**(51) **Int. Cl.**
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(52) **U.S. Cl.** **606/140**(57) **ABSTRACT**

A lung volume reduction system includes a percutaneously, laparoscopically or thoroscopically insertable delivery element comprising a control end which remains outside the body and an insertion end which, when in an operative position, is adjacent to an external surface of a target portion of a lung and a constriction element deployable from the distal end of the delivery element to apply compressive force to an external surface of the target portion of the lung to constrict at least one airway therein and collapse the target portion of the lung.

Correspondence Address:
FAY KAPLUN & MARCIN, LLP
150 BROADWAY, SUITE 702
NEW YORK, NY 10038 (US)

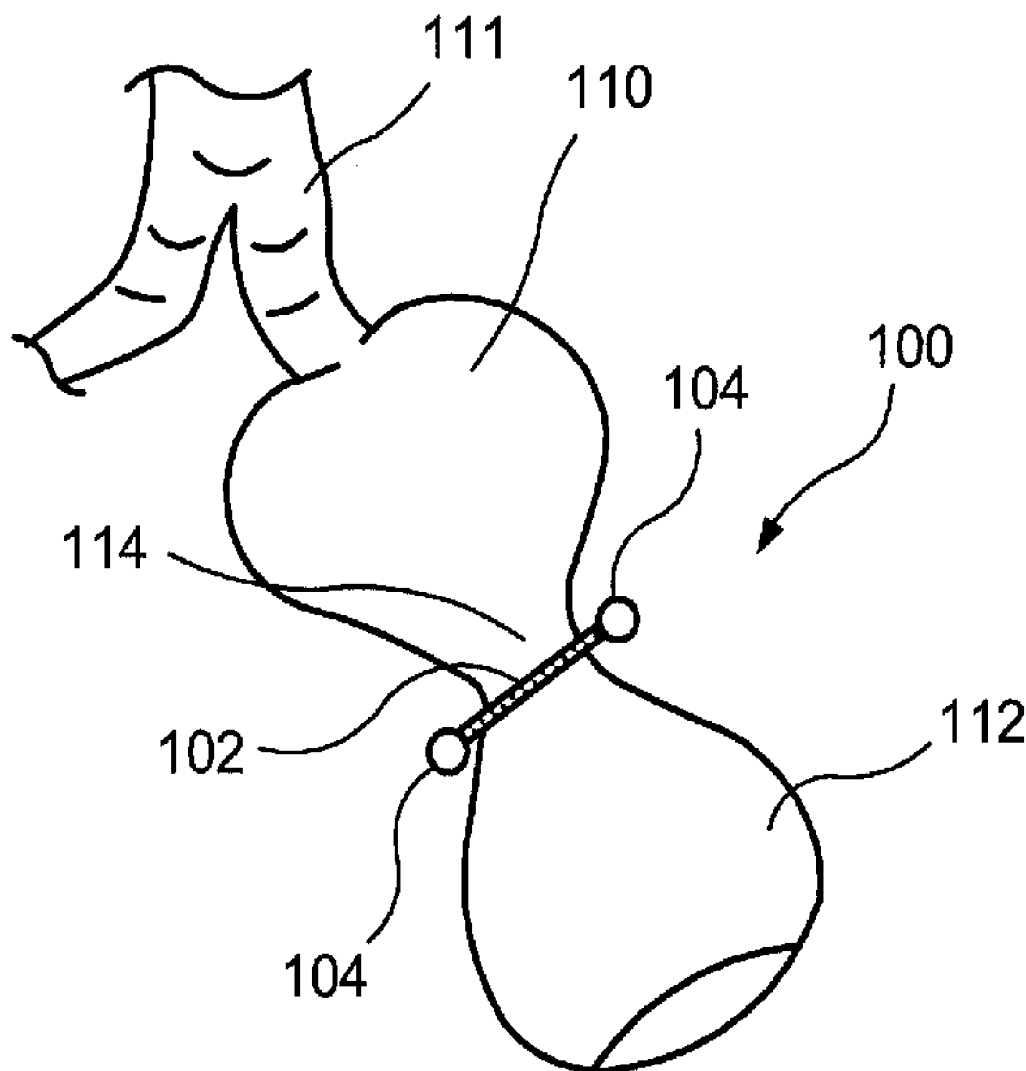
(21) Appl. No.: **12/209,591**(22) Filed: **Sep. 12, 2008**

FIG. 1

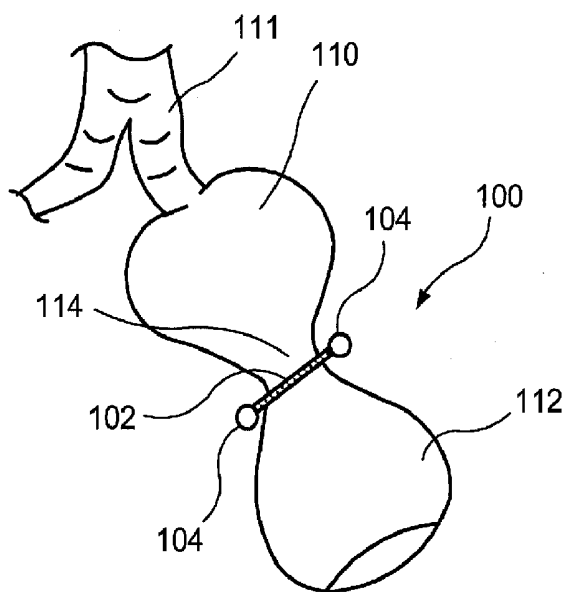


FIG. 2

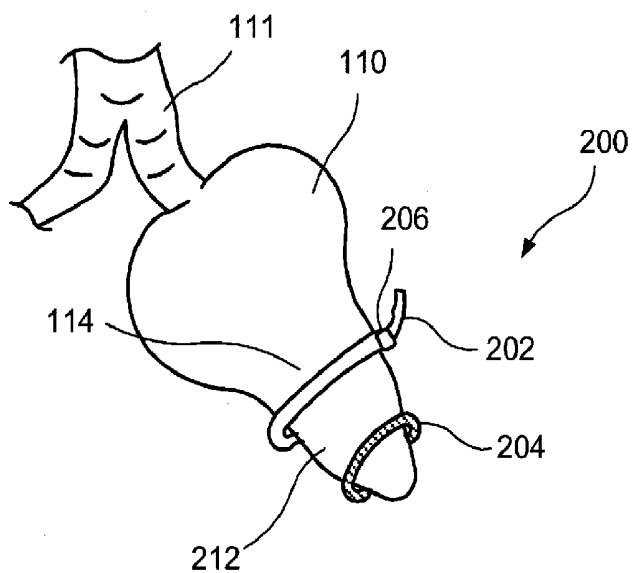
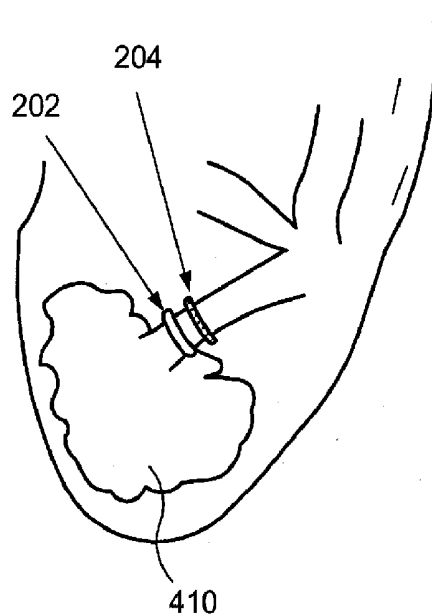


FIG. 3



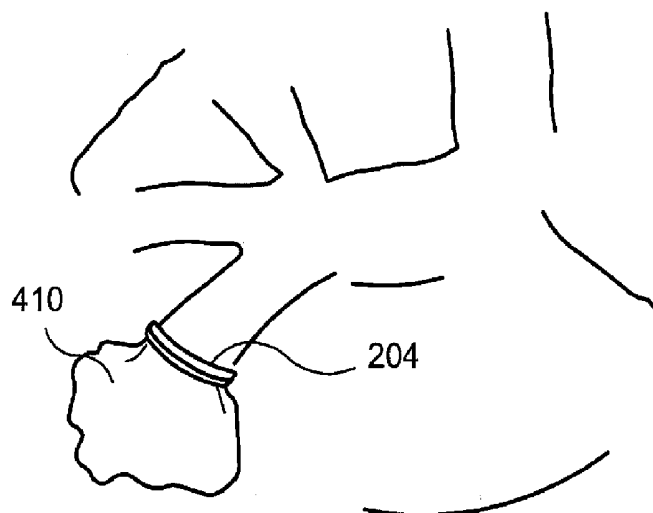


FIG. 4

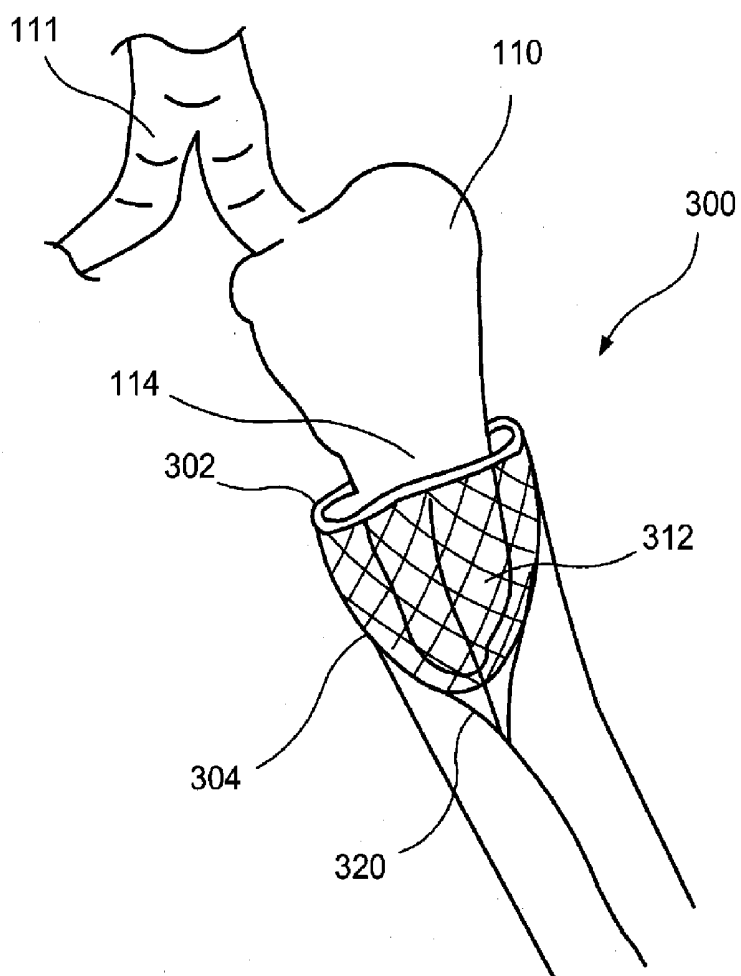
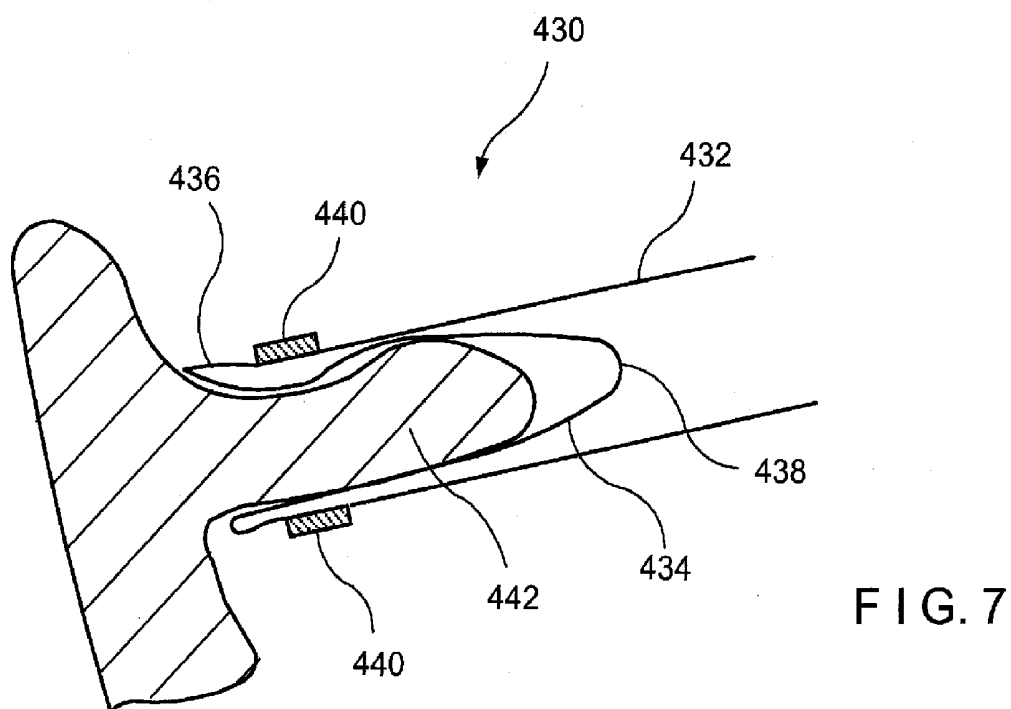
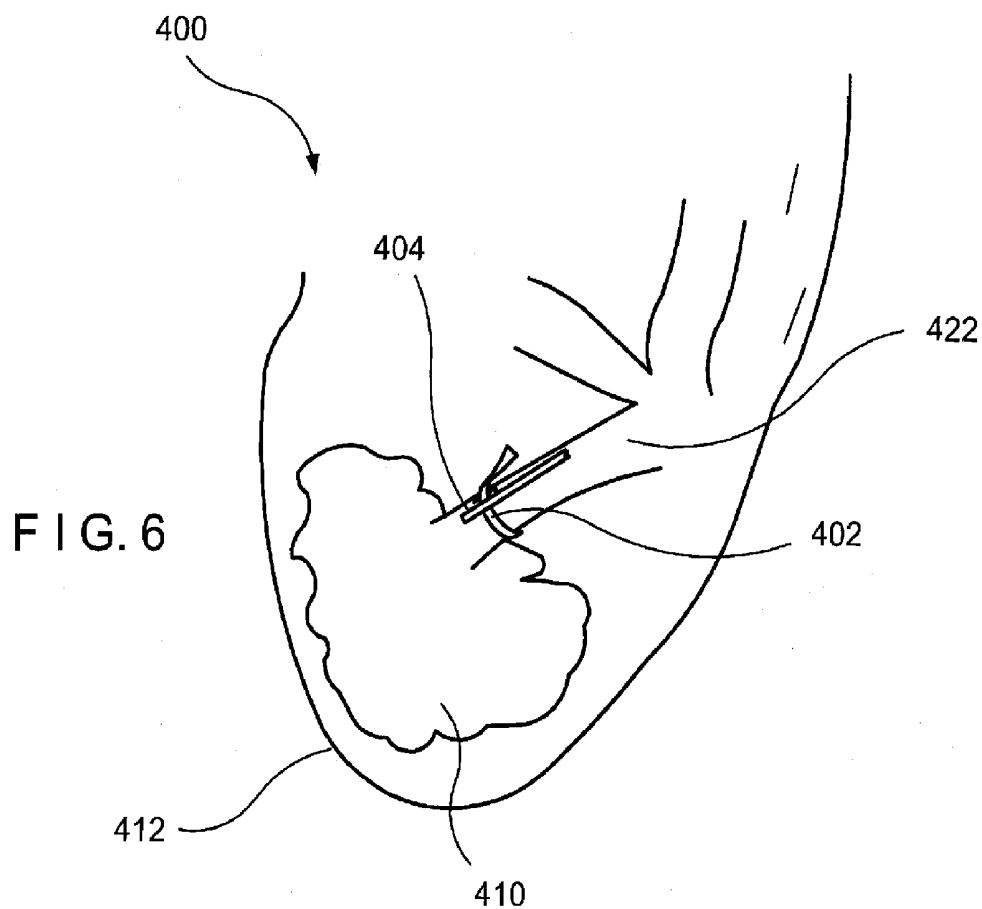


FIG. 5



**COMPRESSION, BANDING AND
PERCUTANEOUS AIRWAY LIGATION OF
EMPHYSEMATOUS LUNG TISSUE**

PRIORITY CLAIM

[0001] This application claims the priority to the U.S. Provisional Application Ser. No. 60/973,269, entitled "Compression, Banding and Percutaneous Airway Ligation of Emphysematous Lung Tissue," filed Sep. 18, 2007. The specification of the above-identified application is incorporated herewith by reference.

BACKGROUND

[0002] Emphysema, a progressive, often incurable disease of the lungs often results from chronic infection or irritation of the bronchial tubes. As the bronchial tubes become irritated, some of the airways may be obstructed, trapping air in the alveoli. As this process continues, the alveoli become enlarged and exchange oxygen for carbon dioxide less efficiently. Furthermore, these expanded portions of the lungs may compress adjacent healthy portions of the lungs interfering with their functioning.

[0003] Lung volume reduction surgery (LVRS) is one treatment used to relieve the symptoms of emphysema by removing diseased portions of the lungs to create more room for the remaining healthy portions. Although LVRS has been shown to improve pulmonary function and the survival rate in selected patients the complications associated with such major, open surgical procedures make LVRS unsuitable for certain patients.

[0004] Minimally invasive procedures have also been employed to achieve results similar to those of LVRS while minimizing the associated complications. These less invasive procedures generally involve depositing in the lungs devices that restrict the flow of air to the diseased portions of the lungs. Often, a bronchoscope or laparoscope is used to deliver the devices obviating the need for surgical openings into the chest cavity.

SUMMARY OF THE INVENTION

[0005] The present invention is directed to a lung volume reduction system comprising a percutaneously insertable delivery element comprising a control end which remains outside the body and an insertion end which, when in an operative position, is adjacent to an external surface of a target portion of a lung and a constriction element deployable from the distal end of the delivery element to apply compressive force to an external surface of the target portion of the lung to constrict at least one airway therein and collapse the target portion of the lung. As would be understood by those skilled in the art, this collapsed condition may, if desired, be continued for a period of time sufficient to necrose the collapsed portion of tissue permanently eliminating the inefficiencies of this diseased portion of tissue from the lung.

DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a diagram showing an embodiment of a device used to collapse a lung according to the present invention;

[0007] FIG. 2 is a diagram showing another embodiment of a device used to collapse a lung using a mechanical tie according to the present invention;

[0008] FIG. 3 is a diagram showing an embodiment of a percutaneous airway lung ligation band according to the present invention, during deployment; and

[0009] FIG. 4 is a diagram showing the lung ligation band of FIG. 3 after deployment; and

[0010] FIG. 5 is a diagram showing a further embodiment of a device used to collapse a desired portion of lung using an elastic bag, according to the present invention;

[0011] FIG. 6 is a diagram showing a further embodiment of a device used to collapse a desired portion of lung according to the present invention; and

[0012] FIG. 7 shows an apparatus according to a further embodiment of the invention for collapsing a desired portion of lung.

DETAILED DESCRIPTION

[0013] The present invention may be further understood with reference to the following description and the appended drawings, wherein like elements are referred to with the same reference numerals. The present invention relates to devices for treatment of emphysema and more specifically relates to devices for reducing the size of diseased lung tissue to improve the functioning of remaining healthy tissue.

[0014] According to embodiments of the present invention, a percutaneous procedure is employed to access diseased regions of the lungs and to deploy thereto devices to reduce the volume of the diseased tissue increasing the efficiency of the healthy tissue.

[0015] The exemplary embodiments of the present invention comprise procedures employing banding and/or compression devices to reduce the volume of emphysematous tissue. Depending on the details of a particular case, these devices may be deployed from outside or within the lung. The exemplary devices according to the present invention isolate targeted tissue from portions of the lungs upstream thereof to reduce the volume by preventing further influx of air. Other devices according to the invention compress the target tissue to decrease its volume.

[0016] FIG. 1 shows an exemplary embodiment of a system 100 for collapsing a target portion of the lung by clamping or pinching a lobe of the lung. The system 100 includes a rivet or peg 102 which is placed into the thoracic cavity and inserted through a target lobe 112 of a lung 110. The rivet or peg 102 is preferably inserted minimally invasively through, for example, a laparoscope or thoracoscope introduced between the ribs into the thoracic cavity via a small incision with a distal end of the peg 102 being inserted through the target lobe 112 and secured in place by tightening to desired dimensions using conventional locking mechanisms or anchoring members 104. For example, the system 100 may include a tube of substantially circular cross-section through which suction may be applied to draw a portion of lung tissue into the tube after which an elastic ligator may be pushed off the distal end of the tube so that the elastic ligator contracts to constrict the portion of the lung which has been drawn into the tube. Alternatively, as would be understood by those skilled in the art, a tie wrap may be placed around a target portion of the lung and then an end of the tie wrap may be drawn out to tighten the tie wrap around the target portion and constrict the target portion of tissue. After the distal end of the peg 102 has passed through the target lobe 112 to a desired position on a side opposite a point of insertion into the target lobe 112, a first anchor member 104 is attached to or, alternatively, deployed from, the distal end of the peg 102 and the target

lobe 112 is compressed against the first anchor member 104 to a desired degree. The distal end of the peg 102 is prevented from being pulled back into the interior of the target lobe 112 by the first anchor member 104 which engages an exterior of the target lobe 112. Compressing the target lobe 112 against the distal end of the peg 102 reduces the volume of the target lobe 112 by creating a neck region 114 of reduced cross-sectional area. When a desired amount of compression of the target lobe 112 has been achieved, a second anchor member 104 is deployed from a proximal portion of the peg 102 to maintain the desired amount of compression of the target lobe 112. After the second anchor member 104 has been deployed, any excess length of the peg 102 may be trimmed away and the laparoscope may be removed. Those skilled in the art will understand that the peg 102 and the anchoring members 104 are preferably adapted to engage portions of the exterior of the target lobe 112 large enough to hold the anchoring members 104 in position against forces applied thereto during respiration and as the patient moves about.

[0017] Constriction by the peg 102 collapses the bronchial passages in the neck region 114 preventing the passage of air to the target lobe 112 to inflate the alveoli contained therein. Thus surrounding healthy portions of the lung may inflate more freely and carry out the exchanges of gases more efficiently. Over time, the target lobe 112 will necrose because of the constriction further reducing its volume. In an alternative example, a peg 102 may be placed within a target lobe 112 and anchored across a target bronchial passage therein to prevent air flow only to that portion of the target lobe 112 served by the target bronchial passage.

[0018] A system 200 to reduce lung volume according to a second embodiment of the invention is shown in FIGS. 2-4. According to this exemplary embodiment, a mechanical element such as a tie or a clamp 202 is placed around a target portion 212 of the lung 110 to separate the target portion 212 from upstream portions of the lung 110 to collapse the target portion 212. The tie or clamp 202 is applied around the lung 110 to compress the target portion 212 of the lung 110 downstream of an airway branch 111. As with the peg 102 of the system 100, the tie or clamp 202 is preferably inserted into the thoracic cavity through a minimally invasive method, such as through a laparoscopic procedure, and may be secured in place by tightening to the correct dimensions using a conventional locking mechanism 206. Alternatively, the tie or clamp 202 may be replaced, or supplemented, by an elastic band 204 or a shape memory element which, when released around a target portion of the target lobe 212 will contract without the need for a locking mechanism to apply compression thereto. For example, the constriction element may be a loop of a shape memory material such as Nitinol formed so that, when deployed it reverts to a memorized shape with a reduced diameter. The elastic bands 204, or other type of compression element, may also be applied through a laparoscopic procedure or other minimally invasive approach. For example, one or more elastic bands 204 may be disposed around a cylinder into which a portion of the target lobe 212 is drawn (e.g., by suction applied thereto) at which point a first one of the elastic bands 204 may be released (e.g., by drawing a trigger line attached thereto) to contract around the portion of the target lobe 212 adjacent to a distal end of the cylinder.

[0019] As shown in FIGS. 3 and 4 the system 200 collapses a target portion 410 of the lung by isolating it from remaining portions of lung to cut-off the supply of air thereto. A constriction element (e.g., a tie or clamp 202 or an elastic band

204) is deployed from a delivery element onto the airway, so that the passage of air is blocked. For example, a tube such as an endoscope (not shown) may be inserted between the ribs into the thoracic cavity via an incision with one or more constriction elements received around a distal end of the endoscope. The distal end of the endoscope preferably includes a hollow chamber into which the target portion 410 may be drawn (e.g., under suction) so that the distal end of the endoscope and the constriction element received thereon surrounds the target portion 410. In this position, the constriction element is moved off of the distal end of the endoscope so that it encircles a portion of the lung upstream of the target portion 410. When the constriction element is an elastic band 204, the band 204 tightens immediately after it passes off of the distal end of the endoscope to constrict the lung tissue therewithin, preventing the flow of air therethrough. Ties or clamps 202 deployed in this manner are then tightened around the lung tissue to prevent the flow of air to the target portion 410. Those skilled in the art will understand that these constriction elements may be formed of bioabsorbable materials which are preferably selected to retain their form until after a time required to achieve a desired therapeutic effect has elapsed. For example, such a bioabsorbable constriction element may be selected to remain in position, as shown in FIG. 4, until the target portion 410 has completely collapsed and the flow passage(s) thereto are sealed. As would be understood by those skilled in the art, the system 200 may deploy the ligating bands 204 using a mechanism substantially similar to an elastic band ligating system for treating esophageal varices as described, for example, in U.S. Pat. No. RE36,629 issued to Zaslavsky, et al., Mar. 28, 2000, the entire disclosure of which is hereby incorporated by reference.

[0020] As shown in FIG. 5, a system 300 according to an additional embodiment of the lung reduction system according to the invention includes an elastic bag or sock 304 which is stretched for placement around a portion of a target lobe 312 of the lung 110. Upon release, the bag 304 contracts to apply a compressive force to a portion of a surface of the target lobe 312 of the lung 110 larger than that affected by the clamp 202 or the ligating band 204. That is, the open end of the bag 304 constricts air flow into the target lobe 312 of the lung 110 as in the prior embodiments while the remaining portions of the bag 304 actively compress the target lobe 312. As would be understood by those skilled in the art, the bag 304 may be designed to apply a compressive force which is substantially equal across the surface area of the target lobe 312 with which it is in contact. Alternatively, the bag 304 may be designed to apply a force which varies over the surface area. For example, the bag 304 may be designed to apply a force which is a maximum along a line which, when the bag 304 is in a desired position on the target portion of the lobe 312, is furthest upstream on the lobe 312 (e.g., at the open end of the bag 304) or to cause the collapse of portions of the target lobe 312 in a desired sequence. In the exemplary embodiment, the bag or sock 304 comprises a band 302 adapted to retain the device in place on the target portion of the lung 110. For example, the band 302 may have an inner surface shaped to grasp the tissue of the lung and prevent it from slipping off the target lobe 312. The band 302 may, for example, be made of an elastic material, or may be tightened mechanically as desired in a manner similar to that described above.

[0021] The bag or sock 304 according to the present invention is preferably made of a bioabsorbable material such as

polyurethane or lycra so that it does not have to be removed after the compressed portion of the target lobe **312** has necrosed to a desired level. As with other embodiments of the present invention, the bag or sock **304** is designed to be placed using minimally invasive techniques. Specifically, the bag or sock **304** can be inserted into the body through a small incision or port on an elongated retractor device. The distal end of the retractor is generally maintained in a closed condition so that the sock **304** can be placed thereover to keep the retractor in a low profile. When the sock **304** is placed adjacent to the target lobe **312**, a handle of the retractor is activated to expand the sock **304** using, for example, three or more arms **320** for ease of placement over the target lobe **312**. The handle of the retractor may be attached, via known means, to the plurality of arms **320** so that, upon activation, the arms extend radially outward from the device. Once the sock **304** is placed in the desired location, the arms of the retractor device may be retracted in order to release the hold on the sock **304**. The arms **320** of the retractor can then be removed from the body in a closed position in order to minimize trauma to the patient.

[0022] As shown with respect to FIG. 6, the exemplary lung reduction system **400** is designed to be performed percutaneously to treat a target portion or lobe **410** of a lung **412**. Those skilled in the art will understand that the percutaneous method may be used in conjunction with an imaging modality, such as, for example fluoroscopy. Alternately, a laparoscopic procedure may be employed to facilitate visual observation during the procedure. As another possibility, the procedure may be performed thoroscopically, via VATS or via the use of SPY fiber technology in one of the working channels of the scope, as those skilled in the art will understand. In this embodiment, the delivery element comprises a percutaneous axial member **404** (e.g., a flexible tube) used to deliver an elastic band **402** or other constriction element to an airway **422** such as a bronchial tube. A distal end of the axial member **404** is introduced into the body and placed adjacent to the airway **422** to be treated while a proximal end of the percutaneous axial member **404** remains outside the body for manipulation by a user for positioning of the distal end over a desired target portion of the lung **412**.

[0023] As would be understood by those skilled in the art, a conventional mechanism, similar to those used for band ligation of esophageal varices, may be used to deploy the elastic band **402** from the axial member **404**, so that the elastic band **402** wraps around and is anchored to a portion of the air passage **422** which had previously been drawn into the axial member **404**. For example, as described above in regard to the embodiment of FIG. 2, a cord extending along the length of the percutaneous rod **404** may be used to pull one elastic band **402** at a time off the axial member **404**, and release it over the air passage **422**. In another embodiment, a longitudinal member may extend along the length of the axial member **404** so that the longitudinal member may slide along the length thereof to individually release the elastic bands **402**. Alternatively, the elastic band **402** may have a length that can be varied by the user, so that it can be elongated to pass over the hyperinflated portion of the lung **410**, and then shortened to tighten around the air passage **422**. The elastic band **402**, when released over the air passage **422**, constricts to cut off air-flow to the hyperinflated target portion or lobe **410** from the rest of the lung **412** leading to necrosis of this target portion or lobe **410**. The elastic band **402** is preferably formed of biodegradable material so that it may remain in place for a substantial amount of time to prevent re-inflation of the target

lobe or portion **410'**, by blocking the air passing through the airway **422**. As would be understood by those skilled in the art, the material of the elastic band **402** is selected to remain in position for a length of time sufficient to collapse the target lobe **410'** to a desired level. In cases where the elastic band is not biodegradable, an additional procedure may be performed to remove the band **402** from the body after the desired level of collapse has been achieved.

[0024] As shown in FIG. 7, a system **430** similar to that described above in regard to FIGS. 3 and 4 may be used to deploy a bag or sock similar to those described above in regard to FIG. 5. The system **430** includes an axial member **432** with a bag or sock member **434** with an open end **436** wrapped around the distal end of the axial member **432**. The closed end **438** of the sock member **434** extends within a lumen of the axial member **432** while an elastic member **440** extending around the open end **436** holds the sock member **434** to the distal end of the axial member **432**. After being advanced to a location adjacent a target portion **442** of lung to be treated in the same manner described above, the target portion **442** of lung is aspirated into the distal end of the axial member **432** via the application of suction or the manipulation of a grasper through the lumen of the axial member and the elastic member **440** is released from the distal end of the axial member **432** to constrict around the target portion maintaining the sock member **434** in position over the target portion **442**.

[0025] The present invention has been described with reference to specific exemplary embodiments. Those skilled in the art will understand that changes may be made in details, particularly in matters of shape, size, material and arrangement of parts without departing from the teaching of the invention. Accordingly, various modifications and changes may be made to the embodiments without departing from the broadest scope of the invention as set forth in the claims that follow. The specifications and drawings are, therefore, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A lung volume reduction system, comprising:
 - a percutaneously insertable delivery element comprising a control end which remains outside the body and an insertion end which, when in an operative position, is adjacent to an external surface of a target portion of a lung; and
 - a constriction element deployable from the distal end of the delivery element to apply compressive force to an external surface of the target portion of the lung to constrict at least one airway therein and collapse the target portion of the lung.
2. The system according to claim 1, wherein the constriction element comprises a peg and wherein the delivery element includes a deploying mechanism advancing the peg through the target portion of the lung and an anchoring mechanism anchoring a distal end of the peg to an exterior surface of the target portion of the lung on a side thereof opposite a side at which the distal end of the peg penetrated the target portion of the lung and anchoring a proximal end of the peg to an exterior surface of the side of the target portion of the lung penetrated by the distal end of the peg.
3. The system according to claim 2, wherein the anchoring mechanism couples a distal anchoring member to the distal end of the peg and a proximal anchoring member to the proximal end of the peg.

4. The system according to claim 2, wherein the deploying mechanism includes an abutting surface compressing the target portion of the lung during advancement of the peg there-through.

5. The system according to claim 2, wherein the peg includes a distal anchoring member coupled thereto for movement between an insertion configuration and a deployed configuration and wherein, after the peg has been inserted through the target portion of the lung, the anchoring mechanism moves the distal anchoring member from the insertion to the deployed configuration.

6. The system according to claim 1, wherein the constriction element comprises an elastic element.

7. The system according to claim 6, wherein, when the insertion end of the delivery element is inserted to the operative position, the constriction element extends around the insertion end.

8. The system according to claim 7, wherein the constriction element is an elastic ligating band which, prior to being deployed, is stretched around the insertion end.

9. The system according to claim 6, further comprising:

a tissue grasping mechanism drawing the target portion of the lung into the insertion end of the delivery mechanism; and

a trigger member extending from the control end of the delivery element to the constriction element so that moving the trigger member releases the element from the insertion end to constrict around tissue received therein.

10. The system according to claim 9, wherein the constriction member comprises an elastic band which constricts around an upstream end of the target portion of the lung to prevent air flow to the target portion of the lung from remaining portions of the lung.

11. The system according to claim 9, wherein the constriction member comprises an elastic bag which constricts the target portion to apply a compressive force across a surface area thereof.

12. The system according to claim 11, wherein the bag comprises a band around an open end thereof which constricts around an upstream end of the target portion of the lung to prevent air flow between the target portion of the lung and remaining portions of the lung.

13. The system according to claim 11, wherein the compressive force applied by the bag is substantially equal across a surface area of the target portion of the lung.

14. The system according to claim 11, wherein the compressive force applied by the bag varies across a surface area of the target portion of the lung.

15. The system according to claim 11, wherein the elastic element is formed of a biodegradable material.

16. A method for treating a respiratory condition, comprising:

a introducing a constriction element into the thoracic cavity via an incision; and

deploying the constriction element against an outer surface of a target portion of the lung to compress at least a part of the target portion.

17. The method according to claim 16, wherein the constriction element is an elastic member further comprising the steps of:

drawing the target portion of the lung into an interior of the elastic member; and

releasing the elastic member so that the elastic member constricts around the target portion.

18. The method according to claim 17, wherein the elastic member is formed as an elastic band and wherein the elastic band is released to constrict around an upstream end of the target portion to prevent air from flowing between the target portion and an upstream portion of the lung.

19. The method according to claim 17, wherein the elastic member is formed as an elastic bag and wherein the elastic bag is released to constrict around an outer surface of the target portion to apply a compressive force thereto.

20. The method according to claim 19, wherein the elastic bag applies a compressive force which is substantially uniform across a surface area of the target portion of the lung.

21. The method according to claim 16, wherein the mechanical element is one of an adjustable tie and a clamp deployable around a neck portion of the target portion of the lung.

22. The method according to claim 16, wherein the compression element comprises at least one peg inserted through the target portion of the lung.

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[标]申请(专利权)人(译)	肉酥亚历山德拉 WOOD MARK 麦金太尔JONt CLERC CLAUDE 莲娜GARY CHU MICHAEL中文		
申请(专利权)人(译)	卢梭亚历山德拉 WOOD MARK MCINTYRE JONt CLERC CLAUDE 莲娜GARY CHU MICHAEL中文		
当前申请(专利权)人(译)	卢梭亚历山德拉 WOOD MARK MCINTYRE JONt CLERC CLAUDE 莲娜GARY CHU MICHAEL中文		
[标]发明人	ROUSSEAU ALEXANDRA WOOD MARK MCINTYRE JON T CLERC CLAUDE LEANNA GARY CHU MICHAEL S H		
发明人	ROUSSEAU, ALEXANDRA WOOD, MARK MCINTYRE, JON T. CLERC, CLAUDE LEANNA, GARY CHU, MICHAEL S. H.		
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摘要(译)

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