JS 44 (Rev. 12/07) (cand rev 1-16-08)

CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. (SEE INSTRUCTIONS ON PAGE TWO OF THE FORM.)

I. (a) PLAINTIFFS

Maquet Cardiovascular, L.L.C

DEFENDANTS

Terumo Corporation and Terumo Cardiovascular Systems Corporation

(b) County of Residence of First Listed Plaintiff Santa Clara County
(EXCEPT IN U.S. PLAINTIFF CASES)

County of Residence of First Listed Defendant
(IN U.S. PLAINTIFF CASES ONLY)
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE LAND INVOLVED.

(c) Attorney's (Firm Name, Address, and Telephone Number)

E-FILING

Bingham McCutchen LLP - James G. Snell (see also attached)
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East Palo Alto, CA 94303-2223
Telephone: (650) 849-4400 / Facsimile: (650) 849-4800

Attorneys (If Known)

ADR

C08 01735

JCS

II. BASIS OF JURISDICTION (Place an "X" in One Box Only)

- ☐ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question (U.S. Government Not a Party)
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES (Place an "X" in One Box for Plaintiff and One Box for Defendant)
(For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated *or* Principal Place of Business In This State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated *and* Principal Place of Business In Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. NATURE OF SUIT (Place an "X" in One Box Only)

CONTRACT
- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment & Enforcement of Judgment
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excl. Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability
- ☐ 196 Franchise

REAL PROPERTY
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

TORTS

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury

PERSONAL INJURY
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- ☐ 365 Personal Injury — Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
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- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

CIVIL RIGHTS
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 444 Welfare
- ☐ 445 Amer. w/Disabilities - Employment
- ☐ 446 Amer. w/Disabilities – Other
- ☐ 440 Other Civil Rights

PRISONER PETITIONS
- ☐ 510 Motions to Vacate Sentence

Habeas Corpus:
- ☐ 530 General
- ☐ 535 Death Penalty
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition

FORFEITURE/PENALTY
- ☐ 610 Agriculture
- ☐ 620 Other Food & Drug
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 630 Liquor Laws
- ☐ 640 R.R. & Truck
- ☐ 650 Airline Regs.
- ☐ 660 Occupational Safety/Health
- ☐ 690 Other

LABOR
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Mgmt. Relations
- ☐ 730 Labor/Mgmt.Reporting & Disclosure Act
- ☐ 740 Railway Labor Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Empl. Ret. Inc. Security Act

IMMIGRATION
- ☐ 462 Naturalization Application
- ☐ 463 Habeas Corpus – Alien Detainee
- ☐ 465 Other Immigration Actions

BANKRUPTCY
- ☐ 422 Appeal 28 USC 158
- ☐ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 840 Trademark

SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))

FEDERAL TAX SUITS
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced and Corrupt Organizations
- ☐ 480 Consumer Credit
- ☐ 490 Cable/Sat TV
- ☐ 810 Selective Service
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 875 Customer Challenge 12 USC 3410
- ☐ 890 Other Statutory Actions
- ☐ 891 Agricultural Acts
- ☐ 892 Economic Stabilization Act
- ☐ 893 Environmental Matters
- ☐ 894 Energy Allocation Act
- ☐ 895 Freedom of Information Act
- ☐ 900Appeal of Fee Determination Under Equal Access to Justice
- ☐ 950 Constitutionality of State Statutes

V. ORIGIN (Place an "X" in One Box Only)

☒ 1 Original Proceeding | ☐ 2 Removed from State Court | ☐ 3 Remanded from Appellate Court | ☐ 4 Reinstated or Reopened | ☐ 5 Transferred from another district (specify) | ☐ 6 Multidistrict Litigation | ☐ 7 Appeal to District Judge from Magistrate Judgment

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing **(Do not cite jurisdictional statutes unless diversity):**
35 U.S.C. § 271

Brief description of cause:
Patent Infringement

VII. REQUESTED IN COMPLAINT:

☐ CHECK IF THIS IS A CLASS ACTION UNDER F.R.C.P. 23

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☒ Yes ☐ No

VIII. RELATED CASE(S) IF ANY

PLEASE REFER TO CIVIL L.R. 3-12 CONCERNING REQUIREMENT TO FILE "NOTICE OF RELATED CASE".

IX. DIVISIONAL ASSIGNMENT (CIVIL L.R. 3-2)
(PLACE AND "X" IN ONE BOX ONLY)

☐ SAN FRANCISCO/OAKLAND ☒ SAN JOSE

DATE
April 1, 2008

SIGNATURE OF ATTORNEY OF RECORD

ATTACHMENT TO CIVIL COVER SHEET
Maquet Cardiovascular, L.L.C. v. Terumo Corporation, et al.

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08 APR -1 AM 9:26
RICHARD W. WIEKING
U.S. DISTRICT COURT
N.D. OF CA. S.J.

E-FILING

ADR

JCS

UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

C08 01735

MAQUET CARDIOVASCULAR, L.L.C., a Delaware L.L.C.,

Plaintiff,

v.

TERUMO CORPORATION, a Japanese corporation and TERUMO CARDIOVASCULAR SYSTEMS CORPORATION, a Delaware corporation,

Defendants.

No.

COMPLAINT FOR PATENT INFRINGEMENT

DEMAND FOR JURY TRIAL

COMPLAINT

Plaintiff Maquet Cardiovascular L.L.C. ("Maquet") hereby alleges for its Complaint against defendants Terumo Corporation and Terumo Cardiovascular Systems Corporation (collectively "Terumo"), on personal knowledge as to its own activities and on information and belief as to the activities of others, as follows:

The Parties

1. Maquet Cardiovascular L.L.C. ("Maquet") is a Delaware limited liability company with its principal office at 170 Baytech Drive, San Jose, California 95134. Maquet is an innovative company focused on developing medical solutions that enable quicker, safer, and more cost effective treatment of patients.

2. Terumo Corporation is a Japanese corporation with its headquarters at 44-1, 2-chome, Hatagaya, Shibuya-ku, Tokyo, 151-0072, Japan. Terumo is a multi-billion dollar, global medical products company. According to Terumo's website, its main business is the "[m]anufacture and sales of medical products and equipment, including pharmaceuticals, nutritional food supplement, blood bags, disposable medical devices, cardiovascular systems, vascular grafts, peritoneal dialysis, blood glucose monitoring system, medical electronic, and digital thermometers." Terumo Corporation - About Terumo - Profile, http://www.terumo.co.jp /English/company/index.html (last visited Mar. 28, 2008).

3. Terumo Cardiovascular Systems Corporation ("TCS") is a Delaware corporation with its principal place of business at 6200 Jackson Road, Ann Arbor, Michigan 48103. On information and belief, TCS is an indirect (through Terumo Medical Corporation) wholly owned subsidiary of Terumo Corporation. On information and belief, TCS is entirely controlled by Terumo Corporation, and operates as a department of Terumo Corporation. TCS maintains a manufacturing facility in California at 1311 Valencia Ave., Tustin, California 92780. According to TCS's website, "Terumo Cardiovascular Systems ... develop[s] and manufacture[s] precision-focused products for the specialized needs of the cardiac surgical team with an emphasis on cardiopulmonary bypass and intraoperative monitoring." Terumo Cardiovascular Systems -- About Us, http://www.terumo-cvs.com/about_us/default.asp (last visited Mar. 28, 2008).

Jurisdiction

4. This Court has jurisdiction over the subject matter of this case pursuant to 28 U.S.C. §§ 1331 and 1338(a) because this is an action for patent infringement arising under the patent laws of the United States, 35 U.S.C. § 1 *et seq*.

5. This Court has personal jurisdiction over Defendant Terumo Corporation based upon, but not limited to, its minimum contacts with this state and/or the activities of TCS, which operates as Terumo Corporation's general agent, in this state. On information and belief, Terumo's accused products are and have been sold in California.

6. This Court has personal jurisdiction over Defendant TCS based upon the physical presence of its Tustin manufacturing facility in this state and its economic activities conducted in and/or directed at this state. On information and belief, Terumo's accused products are and have been sold in California.

Venue and Intra-district Assignment

7. Venue is proper in this division pursuant to 28 U.S.C. §§ 1391(d) and 1400(b) because defendants are subject to personal jurisdiction in this judicial district, having conducted business and committed acts of infringement in this judicial district, and/or are aliens subject to suit in any district.

8. Per Civil Local Rule 3-2(c), this patent infringement action may be assigned on a district-wide basis. Maquet, which has its principal place of business in San Jose, California, requests that this matter be assigned to the San Jose Division.

Background

9. Maquet is the owner of all right, title and interest, by assignment, of U.S. Patent No. Re. 36,043 ("the '043 Patent"), entitled "Endoscope and Method for Vein Removal" and attached as Exhibit A hereto, and U.S. Patent No. 6,830,546 ("the '546 Patent"), entitled "Device and Method for Remote Vessel Ligation" and attached as Exhibit B hereto (collectively, the "Patents in Suit").

10. The Patents in Suit involve innovative technology that allows for a minimally invasive technique for harvesting healthy blood vessels from a patient for use in other parts of

the patient's body, such as in heart bypass surgery, or for use in another patient's body. This is an improvement over conventional vein harvesting methods, including making a long incision along the full length of the vein section for removal. The technology described and claimed in the Patents in Suit allows for a vessel section to be harvested through one or more small incisions, thereby obviating the need to make a long incision along the full length of the vessel section. Among the benefits of this technology is that it reduces trauma and recovery time for the patient.

11. Maquet develops, manufactures, markets, and sells or has sold endoscopic vein harvesting products that use this innovative technology, including: VasoView® HemoPro™, VasoView® 7xB™, VasoView® 7xS™, VasoView® 6, VasoView® 5, VasoView® 4, and other products having similar configurations ("the VasoView® Products").

12. On information and belief, Terumo Corporation uses, imports, distributes, sells, and/or offers for sale, including in the United States and in this Judicial District in the State of California, the VirtuoSaph™ Endoscopic Vein Harvesting System ("VirtuoSaph™") and/or components thereof. Such conduct infringes Maquet's rights in and to the Patents in Suit.

13. TCS uses, imports, distributes, sells, and/or offers for sale, including in the United States and in this Judicial District in the State of California, the VirtuoSaph™ product and/or components thereof. On information and belief, TCS maintains a network of subsidiaries, sales branches, and/or third party distributors that offers to sell and have sold the VirtuoSaph™ product in the United States. Such conduct infringes Maquet's rights in and to the Patents in Suit.

14. The VasoView® Products have been marked with the numbers of the Patents in Suit.

FIRST CAUSE OF ACTION
(Infringement of U.S. Patent No. Re. 36,043)

15. Maquet repeats and incorporates by reference the allegations contained in the paragraphs above.

16. Terumo Corporation and TCS, through their using, importation, selling, and

offering for sale of the VirtuoSaph™ product in the United States, have infringed and continue to infringe the '043 Patent directly, contributorily, and/or by inducement, either literally or under the doctrine of equivalents, in violation of 35 U.S.C. § 271.

17. Maquet has suffered damages due to the acts of infringement by the Terumo defendants in an amount to be established at trial.

18. The Terumo defendants' infringement has been willful and deliberate.

19. Unless enjoined by this Court, Terumo Corporation and TCS will continue to infringe '043 Patent, and Maquet will suffer damages and irreparable harm.

SECOND CAUSE OF ACTION
(Infringement of U.S. Patent No. 6,830,546)

20. Maquet repeats and incorporates by reference the allegations contained in the paragraphs above.

21. Terumo Corporation and TCS, through their using, importation, selling, and offering for sale of the VirtuoSaph™ product in the United States, have infringed and continue to infringe the '546 Patent directly, contributorily, and/or by inducement, either literally or under the doctrine of equivalents, in violation of 35 U.S.C. § 271.

22. Maquet has suffered damages due to the acts of infringement by the Terumo defendants in an amount to be established at trial.

23. The Terumo defendants' infringement has been willful and deliberate.

24. Unless enjoined by this Court, Terumo Corporation and TCS will continue to infringe the '546 Patent, and Maquet will suffer damages and irreparable harm.

Prayer for Relief

25. WHEREFORE, Maquet requests that the Court enter judgment in its favor and against Terumo as follows:

(a) Granting a preliminary and permanent injunction enjoining Terumo Corporation and TCS, and each of their respective officers, agents, representatives, distributors, employees, affiliates, parent and subsidiary corporations, and all those in privity or acting in concert with them, from further infringing, contributing to and/or inducing the infringement of

the Patents in Suit;

(b) Awarding compensatory damages to Maquet, including but not limited to lost profits and/or a reasonable royalty, according to proof at trial;

(c) Awarding treble damages to Maquet, including pursuant to 35 U.S.C. § 284;

(d) Awarding attorneys' fees to Maquet, including pursuant to 35 U.S.C. § 285;

(e) Awarding such other relief as the Court deems just and proper.

Dated: April 1, 2008

BINGHAM McCUTCHEN LLP

By: _____
James Snell
Attorneys for Plaintiff
MAQUET CARDIOVASCULAR, L.L.C.

Jury Trial Demanded

Plaintiff Maquet Cardiovascular, L.LC. hereby demands a jury trial on all issues triable to a jury in this action.

Dated: April 1, 2008

BINGHAM McCUTCHEN LLP

By: _____
James Snell
Attorneys for Plaintiff
MAQUET CARDIOVASCULAR, L.L.C.

EXHIBIT A

US00RE36043E

United States Patent [19]

Knighton

[11] E Patent Number: Re. 36,043

[45] Reissued Date of Patent: Jan. 12, 1999

[54] **ENDOSCOPE AND METHOD FOR VEIN REMOVAL**

[75] Inventor: **David R. Knighton**, Minneapolis, Minn.

[73] Assignee: **Embro Vascular, L.L.C.**

[21] Appl. No.: **585,410**

[22] Filed: **Jan. 11, 1996**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **5,373,840**
Issued: **Dec. 20, 1994**
Appl. No.: **956,904**
Filed: **Oct. 2, 1992**

[51] **Int. Cl.**^{6} **A61B 1/00**

[52] **U.S. Cl.** **600/101**; 600/104; 600/114; 606/157

[58] **Field of Search** 600/101, 104, 600/106, 107, 183, 114; 606/157, 158, 159, 205, 207, 40, 49, 190, 198

[56] **References Cited**

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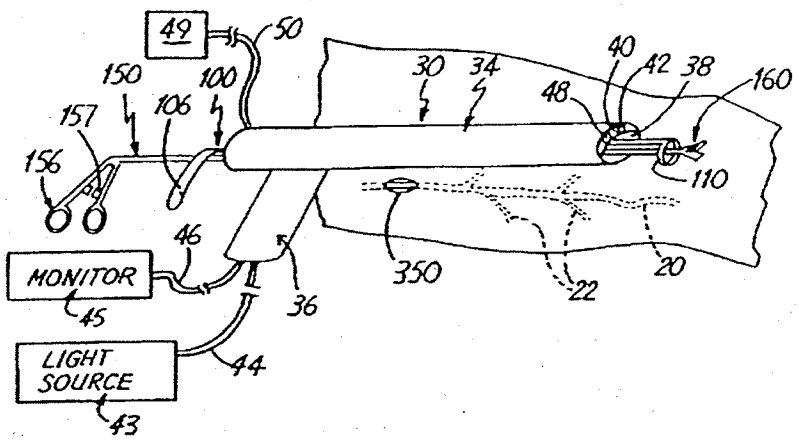
Primary Examiner—Beverly M. Flanagan
Attorney, Agent, or Firm—Popovich & Wiles, P.A.

[57] **ABSTRACT**

An endoscope for use in harvesting blood vessels includes a scope body of the type having a lumen extending longitudinally therethrough which itself has a proximal and a distal end. The endoscope includes means for viewing an area adjacent the distal end of the lumen, and the lumen has a lateral dimension of a size sufficient to accommodate the blood vessel being harvested and at least one tool for use in harvesting the blood vessel. A first end of the blood vessel section to be harvested is exposed through an incision in the patient's body. A dissecting tool and a gripping tool are inserted through the lumen of the endoscope and used to dissect the blood vessel away from the surrounding connective tissue of the patient's body, using the viewing means of the endoscope to view this dissection in process within the patient's body. Additional tools are provided for use through the lumen of the endoscope to remove body fluids and coagulate bleeding tissue, and to sever side branches from the blood vessel to be harvested, as well as to sever a distal end of the blood vessel to be harvested when a desired length of blood vessel has been dissected. Only a single small incision in the patient's body is necessary to harvest a relatively long length of blood vessel in a precise and controlled manner through endoscopic vision using the inventive endoscope and its related tools.

The questions raised in reexamination request No. 90/004,301, filed Jul. 12, 1996, have been considered and the results thereof are reflected in this reissue patent which constitutes the reexamination certificate required by 35 U.S.C. 307 as provided in 37 CFR 1.570(e).

52 Claims, 8 Drawing Sheets



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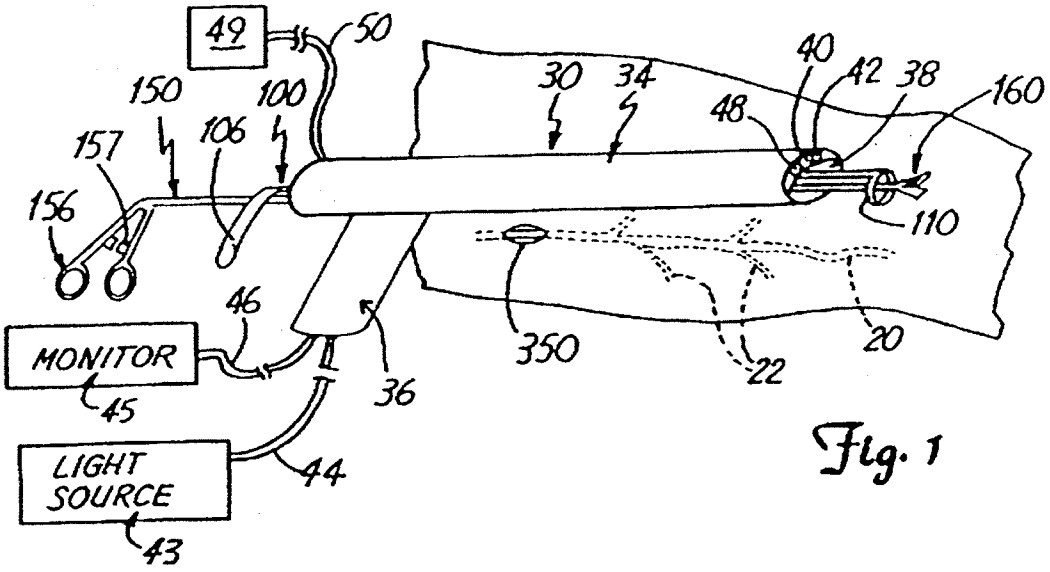


Fig. 1

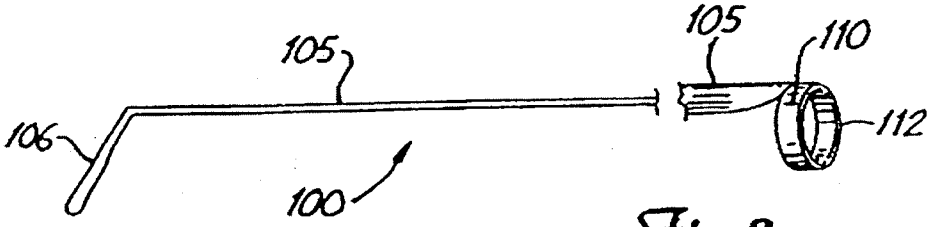


Fig. 2

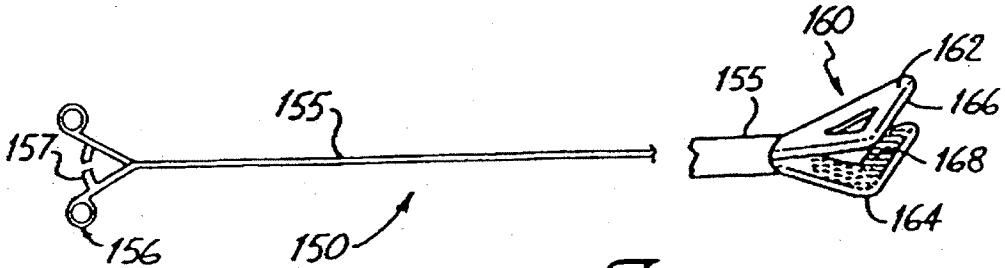


Fig. 3

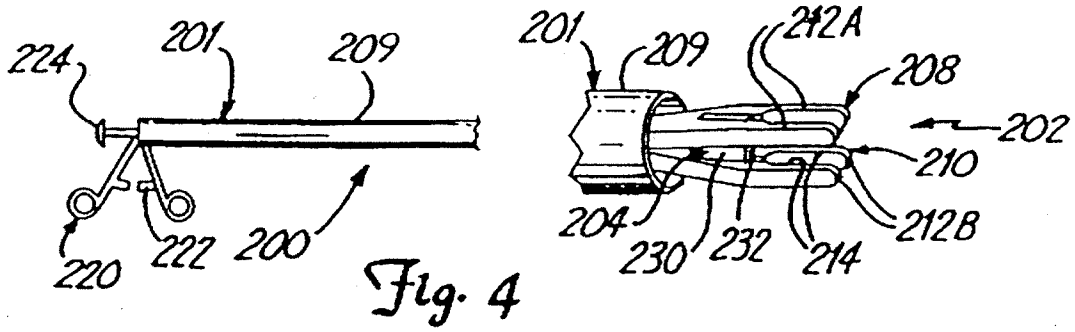


Fig. 4

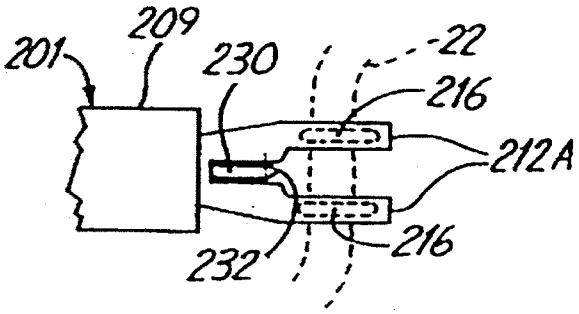


Fig. 4A

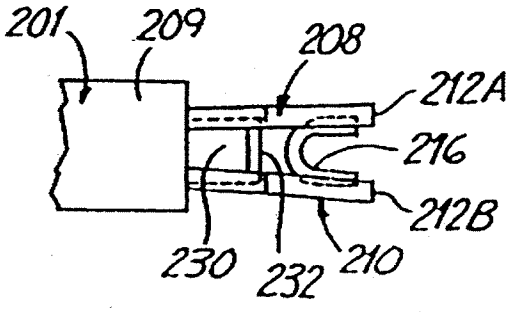


Fig. 4B

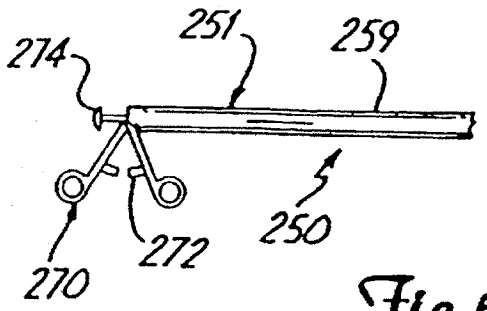
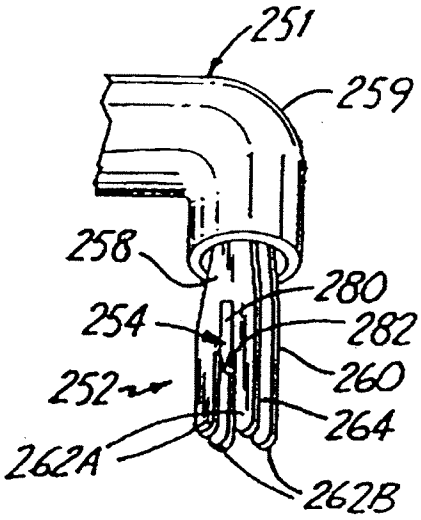

274
251
259
250
272
270

Fig. 5


251
259
258
280
254
282
260
252
264
262A
262B

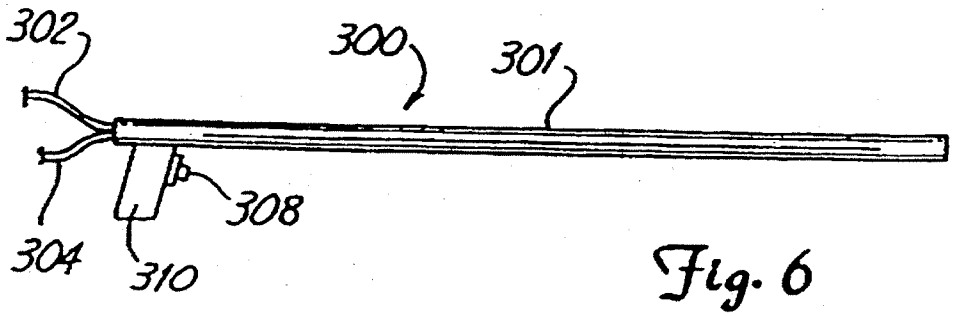

302
300
301
308
304
310

Fig. 6

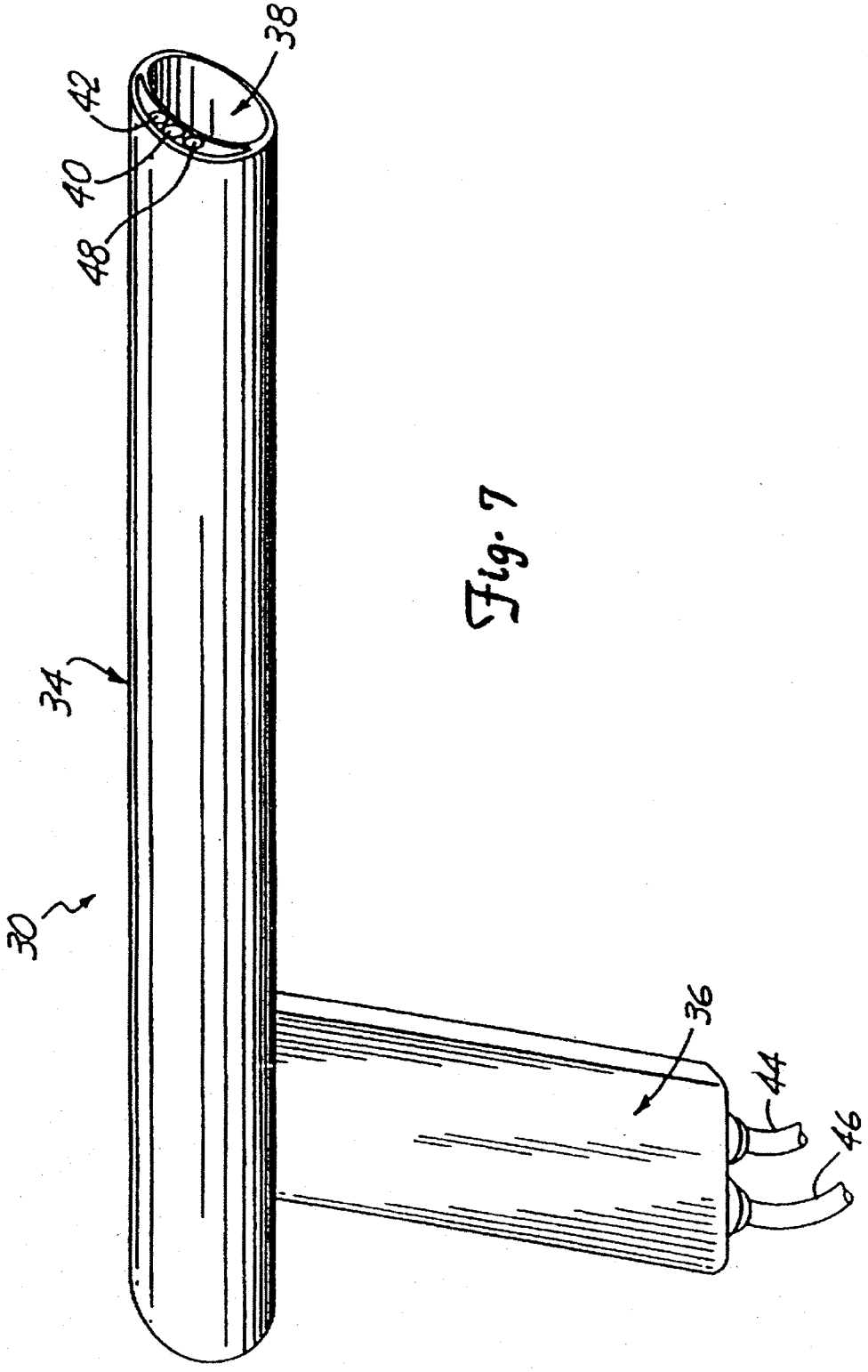


Fig. 7

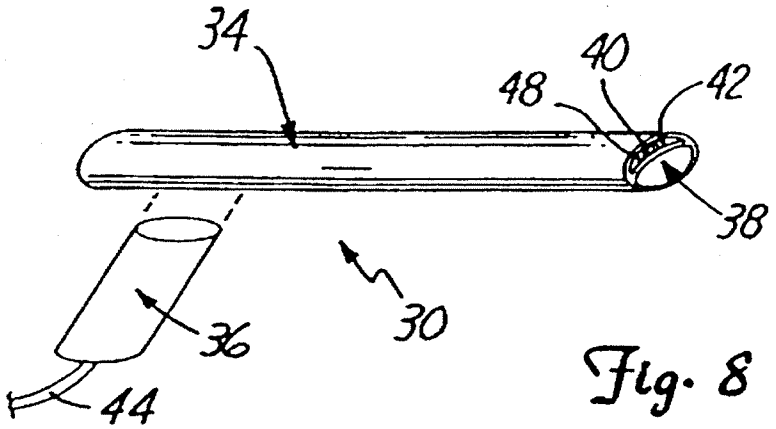

34
40
48
42
38
30
36
44

Fig. 8

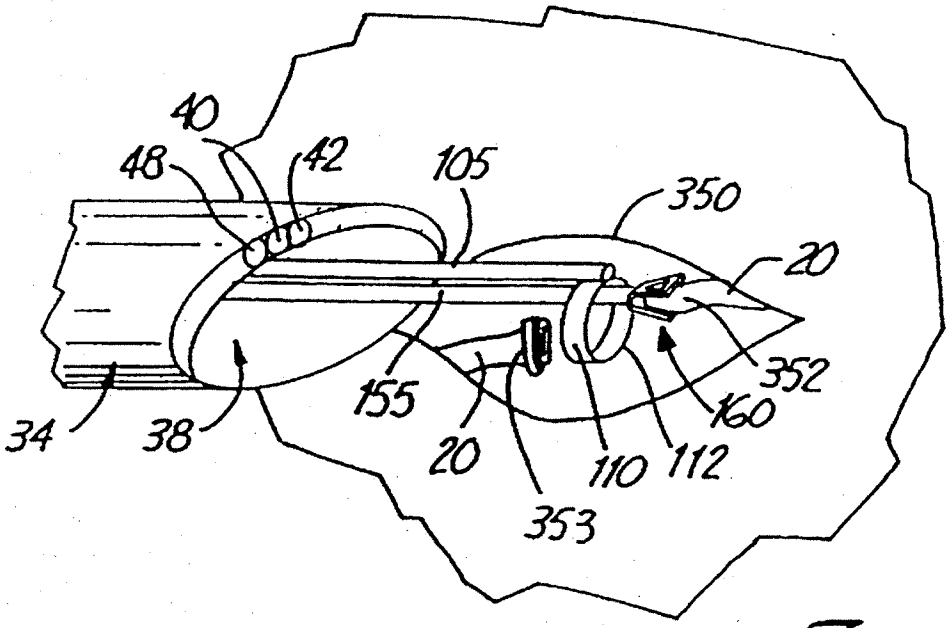

40
48
42
105
350
20
352
160
155
20
110
112
353
34
38

Fig. 9

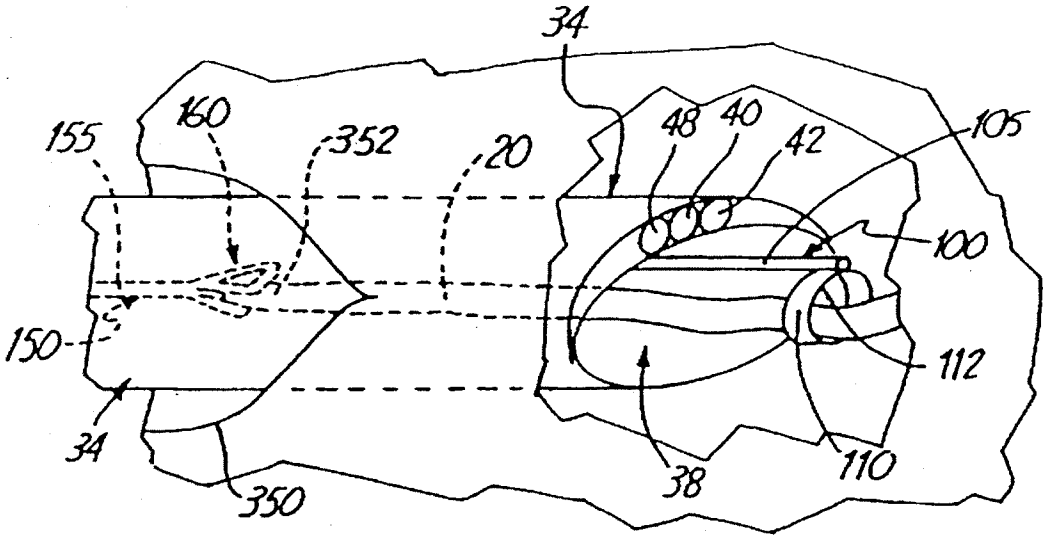

34
155
160
352
20
48
40
42
105
100
150
112
34
350
38
110

Fig. 10

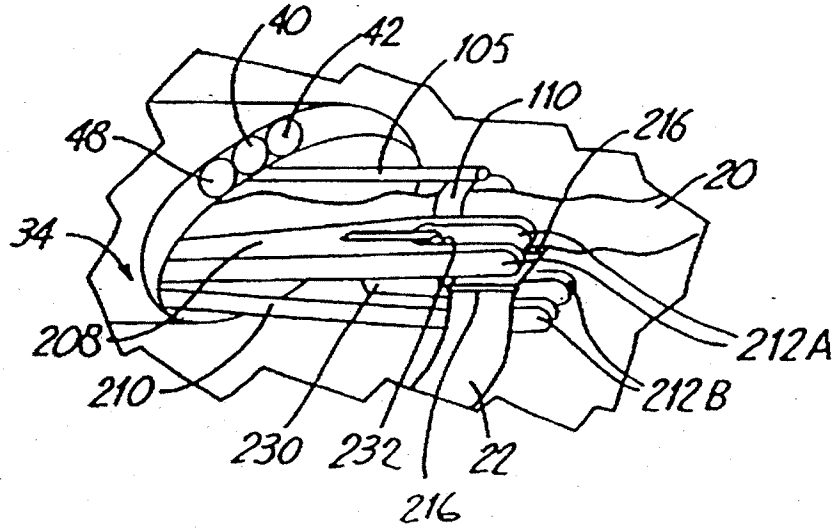

40
42
105
110
216
48
20
34
208
212A
210
212B
230
232
22
216

Fig. 11

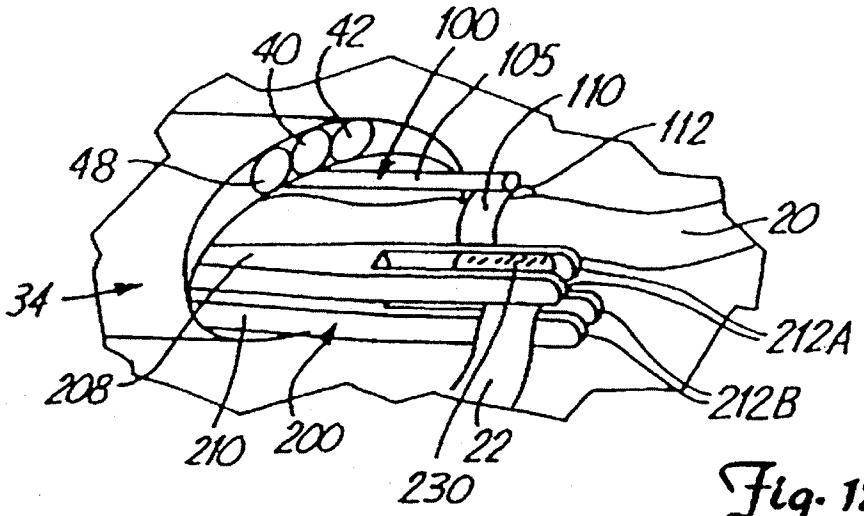

40
42
100
105
110
112
48
20
34
212A
208
212B
210
200
22
230

Fig. 12

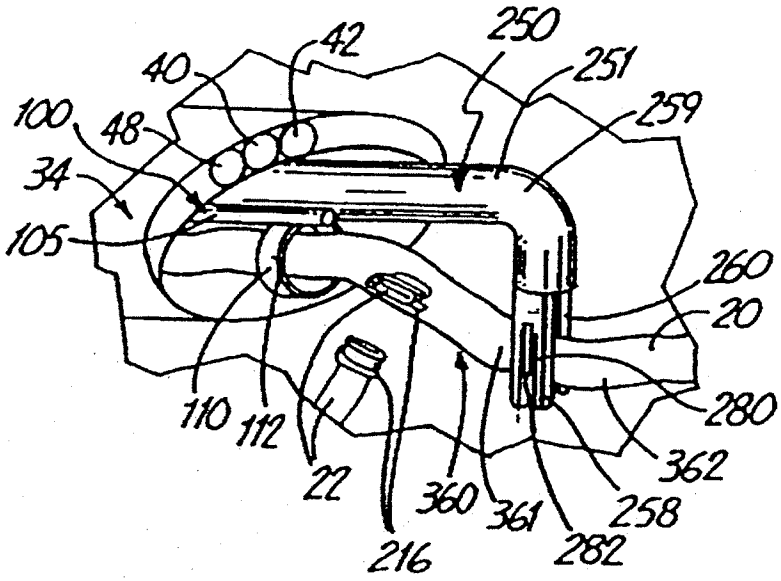

42
250
40
251
259
100
48
34
105
260
20
280
110
112
362
22
360
361
258
216
282

Fig. 13

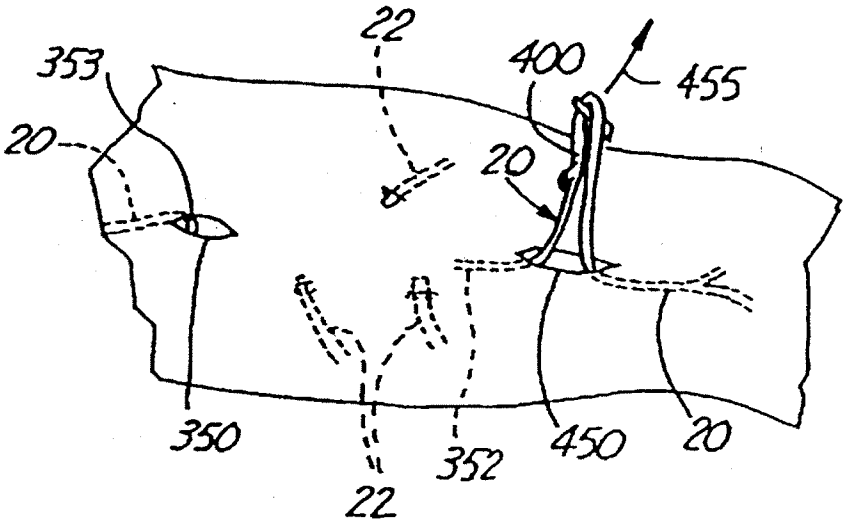


Fig. 14

ENDOSCOPE AND METHOD FOR VEIN REMOVAL

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

The present invention relates generally to surgical instruments. In particular, the present invention relates to a method and instrument for harvesting a section of a blood vessel from a patient.

In certain surgical procedures, it is necessary to remove a section of a blood vessel from a patient for use in another part of the patient's body or for transplanting into a second patient's body. For example, a section of the saphenous vein may be removed for use in coronary bypass surgery. Previously, it has been necessary to make an incision along the full length of the vein section to be removed. The vein is then freed by severing and ligating the branches of the vein, after which the section of the vein can be removed from the patient. The full length incision must then be closed, for example by suturing or staples. Obviously, the harvesting of the vein in this manner leaves disfiguring scars which are cosmetically undesirable. Additionally, the large incision creates a risk of infection to the patient and may not heal properly, especially with those patients who have poor circulation in their extremities. Such an incision may create a chronic wound which will not heal.

Devices for harvesting a section of a blood vessel without creating a full length incision have been suggested. U.S. Pat. No. 4,793,346 to Mindich discloses a device for harvesting a section of a blood vessel by making only small incisions at opposite ends of the blood vessel section. The device includes a guide rod which fits inside of the vein section and a tube having an inner diameter slightly larger than the outer diameter of the vein section to be harvested. The tube has one or more knife blades at the leading edge which are connected to an electrical supply. The vein section is removed by making the incision sufficiently deep so as to expose the ends of the blood vessel section to be harvested. The blood vessel is cut to expose one end, the guide rod is inserted inside the blood vessel section, and the tube is placed over the end of the blood vessel section to be removed. The tube is then pushed along the blood vessel (into the patient) while rotating the tube to sever the branches of the blood vessel with the knife blades mounted at the leading edge of the tube. Electrical current is supplied to the knife blades to heat the blades and thereby cauterize the ends of the severed branches of the blood vessel. The procedure is continued until the tube has reached the second of the two incisions. The blood vessel is exposed and cut from the patient at the second incision, and the tube is then removed from the patient with the blood vessel section inside of the tube. The blood vessel section is then removed from the tube for further treatment and used as desired.

UK Patent Application GB 20 82 459A discloses a device for harvesting a section of a blood vessel similar to that disclosed in the Mindich patent. Again, two incisions are made, one at each end of the blood vessel section to be harvested. A guide rod is inserted into the blood vessel section through one of the incisions and a tube having a cutting element at its operative end is passed over the blood vessel section and guide rod assembly. The tube is rotated as it passes over the blood vessel section to sever the connecting branches. After the tube has passed the entire length of the blood vessel section, the section is cut away through the second incision and the tube is removed from the patient with the harvested section inside the tube.

The blood vessel harvesting devices of the prior art have certain distinct disadvantages. While the prior art devices eliminate the need for a full length incision to remove the blood vessel segment, two incisions, one at each end of the segment to be harvested, are required in order to remove the blood vessel segment. For patients likely to develop chronic wounds, each additional incision increases the risk to the patient, and it is desirable to keep such incisions as close to the patient's trunk as possible and to minimize the number and size of such incisions. Additionally, the prior art devices do not allow for the viewing of the dissection of the blood vessel segment. The physician operating the removal device is unable to see the progression of the dissection and must rely on the guide rod inserted within the blood vessel to guide the cutting instrument in the proper direction. The inability to view the dissection directly increases the risk of damaging the blood vessel segment and the risk of causing injury to the patient.

In addition, it is critical that the segment of blood vessel being harvested is handled with great care since it is destined for reuse (e.g., as an arterial bypass). The blind insertion of a guide rod into the blood vessel damages and likely destroys the endothelium of the vessel. The prior art devices also have the disadvantage of being unable to adequately close off severed branches of the blood vessel and thus are unable to adequately control bleeding. As a result, the patient suffers greater blood loss than is necessary. The prior art devices also may remove more tissue than is necessary because the size of the cutting device is not readily adaptable to changes in the size of the blood vessel.

There is a need for an efficient and effective means for harvesting a section of a blood vessel from the body of a patient. Specifically, there is a need for a device that does not require insertion of any component within the vessel being harvested, and that allows direct viewing of the dissection of the blood vessel segment while at the same time minimizing the size of the incision into the patient's body. Such a device would allow the physician to be much more precise in this procedure, minimize the risk of the patient developing a chronic wound that will not heal, minimize the amount of scarring to the patient's body and maintain the internal integrity of the blood vessel being harvested.

SUMMARY OF THE INVENTION

The present invention is a device and method for harvesting a section of a blood vessel from a patient's body. The invention includes an endoscope of the type having a scope body with a lumen extending longitudinally therethrough, with the lumen having a proximal end and a distal end. The endoscope includes means for viewing an area adjacent to the distal end of the lumen. The lumen has a lateral dimension of size sufficient to accommodate a blood vessel and at least one tool for use in harvesting the blood vessel.

This endoscope for harvesting a blood vessel is relatively uncomplicated. The endoscope allows a section of a blood vessel to be removed by making only a small incision at one end of the blood vessel section to be harvested. The incision exposes a first end of the blood vessel section to be harvested and the first end is inserted through the lumen of the endoscope. The blood vessel is then dissected away from surrounding connective tissue of the patient's body with a dissecting tool inserted through the lumen of the endoscope.

using the viewing means to view the dissection in process as the endoscope is advanced along the blood vessel into the patient's body.

In one preferred embodiment, the endoscope is used with a tool for ligating and cutting branches of the blood vessel segment or a second end of the blood vessel segment. The tool has a distal operative tip with means on the distal tip for applying a ligation clip to a section of the blood vessel specimen which is to be sealed. There are also means on the distal tip for cutting the blood vessel segment between the clip and the first end of the blood vessel segment. The tool eliminates the requirement of making a second incision at the second end of the blood vessel segment to cut the blood vessel segment at the second end so that it may be removed.

The endoscope is ideally suited for patients likely to develop chronic wounds, such as diabetics or other persons with poor circulation, because only one small incision is required to remove the blood vessel segment. The endoscope also allows the physician to directly view the dissection of the blood vessel segment. The ability to directly view the dissection allows the physician to conduct the vessel harvesting procedure much more efficiently and precisely, minimizing the risk of damage the blood vessel and minimizing the risk of injury to the patient.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will further be described with reference to the accompanying drawings where like numbers refer to like parts in several views, and wherein:

FIG. **1** is a perspective view of the inventive endoscope and some related tools, along with a portion of a patient's leg;

FIG. **2** is a side elevational view of a dissecting tool of the present invention, with its distal end enlarged in perspective;

FIG. **3** is a side elevational view of a gripping tool of the present invention, with its distal end enlarged in perspective;

FIG. **4** is a side elevational view of a ligation-cutting tool of the present invention, with its distal end shown enlarged in perspective;

FIG. **4A** is a top plan view of the distal end of the ligation-cutting tool of FIG. **4**;

FIG. **4B** is a side elevational view of the distal end of the ligation-cutting tool of FIG. **4**;

FIG. **5** is a side elevational view of a side-biting ligation-cutting tool of the present invention, with its distal end enlarged in perspective;

FIG. **6** is a side elevational view of a suction-coagulator tool of the present invention;

FIG. **7** is an enlarged perspective view of the endoscope of the present invention;

FIG. **8** is a perspective view of the endoscope of the present invention, showing its two-part assembly;

FIGS. **9–13** are enlarged perspective illustrations showing the distal end of the inventive endoscope and the tools of FIGS. **2–6** in use during the harvesting of a blood vessel; and

FIG. **14** illustrates the partial removal of a partially dissected blood vessel through a second incision, when a long continuous segment of blood vessel is desired to be dissected from the patient's body.

While the above-identified drawing figures set forth one preferred embodiment of the invention, other embodiments are also contemplated, as noted in the discussion. In all cases, this disclosure presents the present invention by way of representation and not limitation. It should be understood

that numerous other modifications and embodiments can be devised by those skilled in the art which fall within the scope and spirit of the principles of this invention. It should be specifically noted that the figures have not been drawn to scale as it has been necessary to enlarge certain portions for clarity.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a device and method for harvesting a section of a vessel from a patient's body for use in another part of the patient's body or for transplanting into a second patient's body. For example, a section of the saphenous vein may be removed for use in coronary bypass surgery. The blood vessel needs to be removed without undue damage to the blood vessel, as well as with minimal damage and trauma to the patient. Although the description herein is directed to the harvesting of the saphenous vein, it is contemplated that the present invention be used in connection with the efficient and effective harvesting of the other lumens and vessels from a patient's body.

THE TOOLS

In FIG. **1**, a saphenous vein **20** (shown in phantom) and endoscope **30** are shown. The saphenous vein **20** travels along the medial side of the foot, leg, and thigh, where it joins with the femoral vein near the groin.

When used to harvest a blood vessel, the endoscope **30** is used in conjunction with several tools. A dissecting tool **100** (FIG. **2**) is used to separate the blood vessel from the surrounding connective tissue. A gripping forceps **150** (FIG. **3**) is used by the physician to hold the blood vessel **20** during the procedure. A ligation-cutting tool **200** (FIG. **4**) is used when severing side branches **22** from the blood vessel **20**. A side-biting ligation-cutting tool **250** (FIG. **5**) is used to transect the blood vessel **20** when the dissection is completed. Finally, a suction-coagulator tool **300** (FIG. **6**) is used to control bleeding during the procedure. Each of these tools is described in detail in the succeeding discussions.

As illustrated in FIGS. **1** and **7**, the endoscope **30** includes an elongated scope body **34** and a handle **36**. A lumen **38** extends longitudinally through the scope body **34** and has a cross-sectional shape which is substantially elliptical. The lumen **38** is of a size large enough to accommodate the blood vessel **20** which is to be harvested and one or more of the tools **100**, **150**, **200**, **250** and **300** longitudinally therein. In one embodiment, the size of the lumen **38** in the scope body **34** is 2 cm wide by 1 cm deep in an elliptical shape, while the scope body **34** itself is 30 to 90 centimeters long. Each of the tools is at least 2 cm longer than the scope body **34**. As illustrated in FIG. **8**, the scope body **34** of the endoscope **30** is selectively securable to the handle **36**. The scope body **34** can thus be made as a disposable unit to eliminate problems with re-sterilization of the portion of the endoscope **30** that enters the patient's body. After use, the endoscope is disassembled, the scope body **34** disposed of, and the handle **36** (containing power connections, lighting means, etc.) saved for repeated use with a new scope body. Alternatively, the scope body has a longitudinal channel therein for reception of the viewing and illumination portions of the endoscope, so that those components are reused while the scope body is disposed after each use. The scope body is provided in a variety of lengths and sizes (cross-sectional) to accommodate patients of different sizes and different blood vessel lengths.

As seen in FIG. **7**, fiber optics illumination source **40** and a fiber optics viewing device **42** are located at the distal end

of the endoscope **30** and positioned adjacent each other such that the area immediately adjacent the distal end of endoscope **30** can be illuminated and viewed by the physician. When connected to the handle **36**, the source **40** is operably connected to an external light source **43** by a suitable light transmission conduit **44** which extends through the endoscope **30**. Similarly, the viewing device **42** is operably connected to an external monitor **45** by a suitable image transmission conduit **46** which extends through the endoscope **30**. The physician views the area adjacent the distal end of endoscope **30** using the illumination source **40** and the viewing device **42** by use of the viewing monitor **45** (FIG. **1**) which is connected to the endoscope handle **36** through the conduit **46**. The monitor **45** may take several forms, such as a television monitor or an eye-piece worn by the physician, as is conventional. The endoscope body **34** also has an irrigation channel **48** extending therethrough. The irrigation channel is operably coupled to an external source of irrigant **49** via a suitable conduit **50**. A distal open end of the irrigation channel is positioned adjacent the distal ends of the fiber-optic illumination source **40** and the viewing device **42**, as seen in FIG. **1**.

Each of the tools **100**, **150**, **200**, **250** and **300** to be used with the endoscope **30** are of a size small enough to fit through the lumen **38** of the scope body **34** while a blood vessel **20** is also in the lumen **38**. The tools **100**, **150**, **200**, **250** and **300** are also long enough to allow the physician to comfortably manipulate them through the lumen **38** (i.e., the tools **100**, **150**, **200**, **250** and **300** are longer than the lumen **38**).

The dissecting tool **100** (FIG. **2**) is used to aid in separating the vessel being harvested from the surrounding tissue. The dissection tool **100** has an elongated shaft **105**, with a handle **106** attached to the proximal end of the shaft **105** and an annular dissecting ring **110** attached to the distal end of shaft **105**. The dissecting ring **110** is oriented such that a plane defined by the dissecting ring **110** is generally perpendicular to the longitudinal axis of the shaft **105**. The size of dissecting ring **110** is large enough to fit over the exterior of the blood vessel **20**. The dissecting ring **110** has a rounded distal edge **112** used to separate the blood vessel **20** from the surrounding connective tissue as the dissecting tool **100** is advanced over the blood vessel **20**. The dissecting tool **100** is provided in a plurality of sizes for different sizes of blood vessels. Typical sizes for such tools would have inside diameters of 4 mm, 5 mm, and 6 mm.

The gripping tool **150** (FIG. **3**) is used to hold and retain the vessel being harvested during the procedure. The gripping tool **150** has an elongated shaft **155**, with a handle **156** attached to a proximal end of the shaft **155** and a gripping mechanism **160** attached to a distal end of the shaft **155**. The handle **156** is preferably a scissors-type handle to actuate the gripping mechanism **160** at the distal end of the body **158** and includes a latching mechanism **157** which allows the gripping mechanism to be locked in a set position (e.g., in a "gripping" position). The shaft **155** transmits the actuating movement from the handle **156** to the gripping mechanism **160**. The gripping mechanism **160** includes a first jaw **162** and a second jaw **164** which oppose each other. When the gripping handle **156** is operated by the physician, the first jaw **162** and the second jaw **164** are moved toward each other and may be used to grip the blood vessel **20** between gripping surfaces **166** and **168** thereon. The jaws **162** and **164** are small enough to fit through the dissecting ring **110** on the dissecting tool **100**.

The ligation-cutting tool **200** (FIGS. **4**, **4A** and **4B**) is used to sever and seal side branches on the vessel being harvested. The ligation-cutting tool **200** has an elongated shaft **201**, with a ligation clip applicator **202** and a cutting mechanism **204** at the distal end of the shaft **201**. The ligation clip applicator **202** includes a first yoke **208** and a second opposed yoke **210**. Each yoke **208** and **210** is in turn divided into two sections; each yoke **208** and **210** is forked at its distal end, forming two opposed prongs **212A** and **212B** on the yokes **208** and **210**, respectively. The prongs **212A** and **212B** on yokes **208** and **210** are parallel to each other and generally aligned with the longitudinal axis of the ligation-cutting tool **200**. The yoke **208** and **210** and the prongs **212A** and **212B** thereon oppose each other and serve to apply ligation clips **216** (see FIGS. **4A** and **4B**) to a side branch **22** being severed. The opposing prongs **212A** and **212B** of each yoke **208** and **210** contain grooves **214A** and **214B**, respectively, to securely hold a ligation clip **216** therein. When the ligation clips **216** are thus held between the opposing prongs **212A** and **212B** of yokes **208** and **210**, the generally U-shaped ligation clips **216** aid the physician in properly aligning the ligation-cutting tool **200** and the side branch **22** to be ligated by providing an abutment for the side branch **22** when the side branch **22** is positioned between the yokes **208** and **210**. When the yokes **208** and **210** are biased towards each other in a conventional manner, the ligation clips **216** are deformed to clamp onto the side branch **22** therebetween and the blood flow through the side branch **22** is halted at two slightly spaced apart points (e.g., two clips are applied approximately 0.25 inches apart). When the ligation clip applicator **202** is activated and the yokes **208** and **210** clamp the ligation clips **216** onto the side branch **22**, the side branch **22** is also held securely for cutting the side branch **22**.

The cutting mechanism **204** on the ligation-cutting tool **200** includes a cutting blade **230** aligned between the prongs **212A** and **212B** and proximal to the ligation clips **216**. The cutting blade **230** is normally retracted (as seen in FIGS. **4**, **4A** and **4B**) to allow the side branch **22** to be positioned properly between the yokes **208** and **210**. A cutting edge **232** of the blade **230** faces the distal end of the ligation-cutting tool **200**, and the cutting motion of the blade **230** is in a distal direction (e.g., towards the side branch **22**). The blade **230** is wide enough to completely sever the side branch **22** between the two yokes **208** and **210**. The cutting mechanism **204** is activated by the physician (as described below) after the side branch **22** has been ligated (i.e., the side branch **22** has been clipped shut and blood flow halted) and while the side branch is still held securely in the yokes **208** and **210**. After the blade **230** has severed the side branch **22**, the blade **230** returns into its original retracted position.

The ligation clip applicator **202** and the cutting mechanism **204** are both actuated by mechanisms at the proximal end of the shaft **201** of the ligation-cutting tool **200**. The ligation clip applicator **202** is preferably actuated by a scissors-type handle **220**. By squeezing the scissors-type handle **220**, the physician causes each set of prongs **212A** and **212B** on the yokes **208** and **210** to be moved together, thereby compressing their respective ligation clips **216** about the side branch **22** of the blood vessel **20**, as described above. The scissors-type handle **220** includes a latching mechanism **222** which serves to secure the handle **220** and thus the ligation clip applicator **202** in a closed or clamped position. While the ligation clip applicator **202** is held in a clamped position, the cutting mechanism **204** is actuated, preferably by a plunger **224** located at the proximal end of the ligation-cutting tool **200**. The plunger **224** is operably connected to the cutting blade **230**, and biased proximally to urge the blade **230** into its normally retracted position. By

moving the plunger **224** distally, the physician causes the cutting blade **230** to likewise move distally and cut the side branch **22** of the blood vessel **20** which is retained between the yokes **208** and **210**. When the physician releases the plunger **224**, the plunger **224** (and thus the cutting blade **230**) retracts to its original position. Manipulation of the handle **220** then separates the prongs **212**A and **212**B, leaving the clip in place on the severed portions of the side branch **22**, and the ligation-cutting tool **200** is removed or relocated for reuse (the clips may be fed into place in the grooves of the prongs from a suitable clip magazine (not shown) to enable multiple ligations without removing the tool from the body).

The shaft **201** of the ligation-cutting tool **200** is a slender member that is longer than the lumen **38** of the endoscope **30**. A housing **209** covers those mechanisms on the shaft **201** that transmit the manipulations of the handle **220** and the plunger **224** at the proximal end of the ligation-cutting tool **200** to the clipping and cutting motions, respectively, at the distal end of the ligation-cutting tool **200**.

The side biting ligation-cutting tool **250** (FIG. **5**) is used to sever and seal the distal end of the vessel being harvested. The side-biting ligation-cutting tool **250** is identical in operation to the ligation tool **200**, except that the operative components at the distal end of the tool **250** are oriented generally normally to the axis of the tool **250**. As seen in FIG. **5**, the side biting ligation-cutting tool **250** has an elongated shaft **251**, with a ligation clip applicator **252** and a cutting mechanism **254** at the distal end of shaft **251**. The ligation clip applicator **252** includes a first yoke **258** and a second, opposed yoke **260**. Each yoke in turn is forked at its distal end, forming two opposed prongs **262**A and **262**B, respectively. The prongs are aligned generally parallel and each has inner grooves **264** to retain ligation clips between each opposed pair of prongs **262**A and **262**B. The structure and operation of the ligation clip applicator **252** is similar to that illustrated in FIGS. **4**A and **4**B for the ligation-cutting tool **200**.

The yokes **258** and **260** and the prongs **262**A and **262**B thereon oppose each other and serve to apply ligation clips (not shown in FIG. **5**) to the distal end of the segment of the blood vessel being severed. When the ligation clips are thus held between the opposing prongs **262**A and **262**B of yokes **258** and **260**, the generally U-shaped ligation clips aid in positioning and properly aligning the side biting ligation-cutting tool **250** and the blood vessel to be transected by providing an abutment for the blood vessel when the blood vessel is positioned between the yokes **258** and **260**. When the yokes **258** and **260** are moved towards each other, the ligation clips are clamped onto the blood vessel therebetween and the blood flow through the blood vessel is halted at two slightly spaced-apart points (e.g., two clips are applied approximately 0.25 inches apart). When the ligation clip applicator **252** is activated and the yokes **258** and **260** clamp the ligation clips onto the blood vessel, the blood vessel is also held securely for cutting the blood vessel.

The cutting mechanism **254** on the side biting ligation cutting tool **250** includes a cutting blade **280** aligned between the prongs **262**A and **262**B. Again, the structure of the cutting mechanism for the tool **250** is quite similar to that illustrated in FIGS. **4**A and **4**B for the ligation-cutting tool **200**. The blade **280** is positioned such that a cutting edge **282** of the blade **280** does not interfere with the alignment of the blood vessel between the yokes **258** and **260**. The cutting blade **280** is normally retracted (as seen in FIG. **5**) to allow the blood vessel to be positioned properly between the yokes **258** and **260**. The cutting edge **282** of the blade **280** faces in a transverse direction from the shaft **251** of the side biting ligation-cutting tool **250**, and the cutting motion of the blade **280** is in a transverse direction (e.g., toward the blood vessel). The blade **280** is wide enough to complete sever the blood vessel between the two yokes **258** and **260**. The cutting mechanism **254** is activated after the blood vessel has been ligated (i.e., the blood vessel has been clipped shut and blood flow halted) and while the blood vessel is still held securely in the yokes **258** and **260**. After the blade **280** has severed the blood vessel, the blade **280** returns to its original retracted position.

The primary difference between the tool **200** and tool **250** is that the distal operative portion of the tool **250** is oriented at an angle generally ninety degrees opposed to the axis of the shaft **251** of the tool **250**. The yokes **258** and **260** are thus oriented to straddle a blood vessel extending generally parallel to the shaft **251** to apply ligation clips thereto. After clips are applied, the yokes continue to hold the blood vessel to permit severing of the vessel using the blade **280**. Other than the revision in orientation of the distal portion of the ligation-cutting tool **250**, it operates in the same manner as the ligation-cutting tool **200**.

The ligation clip applicator **252** and the cutting mechanism **254** are both actuated by mechanisms at the proximal end of the shaft **251** of the ligation-cutting tool **250**. The ligation clip applicator **252** is preferably actuated by a scissors-type handle **270**. Squeezing of the scissors-type handle **270** causes each pair of prongs **262**A and **262**B on the yokes **258** and **260** to move together, thereby compressing their respective ligation clips about the blood vessel. The scissors-type handle **270** includes a latching mechanism **272** which serves to secure the handle **270** and thus the ligation clip applicator **252** in a closed or clamped position. While the ligation clip applicator is held in a clamped position, the cutting mechanism **254** is actuated, preferably by a plunger **274** located at the proximal end of the ligation-cutting tool **250**. The plunger **274** is operably connected to the cutting blade **280**, and biased proximally to urge the blade **280** into its normally retracted position. By moving the plunger **274** distally, the physician causes the cutting blade **280** to likewise move distally and cut the blood vessel which is retained between the yokes **258** and **260**. When the physician releases the plunger **274**, the plunger **274** (and thus the cutting blade **280**) retracts to its original position. Manipulation of the handle **270** then separates the prongs **262**A and **262**B, leaving the clips in place on the severed portions of the blood vessel, and the ligation cutting tool **250** is removed.

The shaft **251** of the side biting ligation-cutting tool **250** is a slender member that is longer than the lumen **38** of the endoscope **30**. A housing **259** covers those mechanisms on the shaft **251** that transmit the manipulations of the handle **270** and the plunger **274** at the proximal end of the side biting ligation-cutting tool **250** to the clipping and cutting motions, respectively, at the distal end of the side biting ligation-cutting tool **250**.

The suction-coagulator tool **300** (FIG. **6**) is used to remove body fluids (e.g., blood) and reduce bleeding during the vessel harvesting procedure, and is of the type generally known in the art for this procedure. The suction-coagulator tool **300** has an elongated shaft **301** and includes a handle **310** attached to the proximal end of shaft **301**. A suction tube **302** is attached to the proximal end of shaft **301** and extends to the distal end of shaft **301**. At the distal end of shaft **301** the suction tube **302** is open for suctioning body fluids. Also attached to the proximal end of shaft **301** is a power cable **304** for supplying power for tissue coagulation. When button

308 on handle 310 is activated, the power is supplied to the distal end of shaft 301 to cauterize bleeding tissue, and thus to stop bleeding. The suction-coagulator tool 300 controls bleeding in two ways. The suction tube 302 may be used alone to suction any body fluids from the dissection area, or the coagulator may be used to cauterize the bleeding tissue.

METHOD OF USE

The endoscope 30 and accompanying tools 100, 150, 200, 250 and 300 are used in combination for harvesting a vessel. After proper preparation of the incision site, the physician makes a small incision 350 (e.g., 3 cm long) over the proximal aspect of the blood vessel to be harvested (see FIGS. 1 and 9). The blood vessel 20 is exposed and dissected for a short length under direct vision. As seen in FIG. 9, the blood vessel 20 is then severed to expose a free end 352 and a free end 353 (which may be clipped as shown in FIG. 9). For example, to remove a saphenous vein, the incision 350 will be made at the groin over the saphenous vein and the vein will be dissected free from the junction of the common femoral vein. As shown in FIGS. 1 and 9, the gripping forceps 150 is inserted through the dissecting ring 110 of the dissecting tool 100, and the assembly of the dissecting tool 100 and the gripping forceps 150 is inserted through the lumen 38 of the endoscope 30 such that the distal ends of the dissecting tool 100 and gripping forceps 150 extend beyond the distal end of the lumen 38. The physician then grasps the free end 352 of the blood vessel 20 with the gripping forceps 150 and holds it under tension. The dissecting tool 100 is then advanced distally (together with the endoscope 30) over the distal end of the gripping forceps 150 and over the blood vessel 20. As the dissecting tool 100 is manipulated by the physician, the blood vessel 20 is dissected away from the surrounding connective tissue.

As illustrated in FIG. 10 (which has a portion of the patient's body broken away to show the invention in operation), the dissection process proceeds distally along the blood vessel 20, and the endoscope 30 is advanced along with the dissecting tool 100 into the incision 350. Until this point, the physician has been viewing the procedure under direct vision. Now, the physician switches to viewing the dissection process (occurring at the area immediately adjacent the distal end of the lumen 38) through the fiber optic viewing device 42 located at the distal end of the scope body 34 of the endoscope 30. The illumination source 40 provides adequate lighting for the physician to view the dissection and tool operations occurring within the patient via the monitor. Irrigant is introduced as necessary through the irrigation channel 48 of the endoscope 30 to keep blood or other body tissue from obscuring vision adjacent the distal end of the scope body 34 of the endoscope.

As the dissection tool 100 is advanced along the blood vessel 20, a side branch 22 of the blood vessel 20 may be encountered before the desired length of blood vessel 20 has been dissected. When the physician reaches a side branch 22 before obtaining the desired length of blood vessel 20, the ligation-cutting tool 200 is employed to sever the side branch 22 from the vessel being harvested (blood vessel 20).

When a side branch 22 is reached, the physician stops advancing the dissecting tool 100 and endoscope 30 and, if necessary, withdraws the dissecting tool 100 proximally from the side branch 22 to provide room for operation of the ligation-cutting tool 200. The ligation-cutting tool 200 is inserted into the proximal end of the lumen 38 and advanced distally through the lumen 38 and into the area distal of the scope body 34 of the endoscope 30. Using the illumination source 40 and the viewing device 42, the physician positions the ligation-cutting tool 200 over the side branch 22 such that the side branch 22 is sitting in the yokes 208 and 210 (see FIG. 11). The physician then manipulates the handle 220 of the ligation-cutting tool 200 to actuate the ligation clip applicator 202. As the prongs 212A and 212B on each of the yokes 208 and 210 move toward each other, the ligation clips 216 are clamped about the side branch 22, thereby stopping blood flow through the side branch 22.

While the side branch 22 is held securely between the yokes 208 and 210 of the ligation clip applicator 202, the physician pushes the plunger 224 to activate the cutting mechanism 204. As shown in FIG. 12, the cutting blade 230 thus moves distally into and through the side branch 22, thereby severing the side branch 22 from the blood vessel 20 between the ligation clips 216. When the plunger 224 is released by the physician, the cutting blade 230 returns to its original retracted position. The handle 220 is then manipulated to separate the prongs 212A and 212B, and the ligation-cutting tool 200 is withdrawn proximally through the lumen 38 of the endoscope 30. The ligation-cutting tool 200 may then be prepared to be used again later in the procedure (i.e., reloaded with additional clips 216), if required.

After the ligation-cutting tool 200 has been removed from the endoscope, the dissecting tool 100 and endoscope 30 are again advanced distally along the blood vessel 20 (as previously described) until another side branch is reached. In this regard, the dissecting ring 110 is large enough to pass over the clipped and severed stumps of any side branches 22 which extend from the blood vessel 20. The ligation-cutting tool 200 is then used as previously described to sever additional side branches from the blood vessel 20. The procedure is repeated until the desired length of blood vessel 20 has been dissected free from the surrounding tissue and side branches. During the dissection procedure, the suction-coagulator tool 300 is used as required to control bleeding, again under the constant vigilance of the physician through the endoscope 30. During the entire procedure, the blood vessel 20 has been held in tension by the physician via the gripping tool 150. In addition, as more and more of the blood vessel 20 becomes dissected, the endoscope 30 is advanced distally into the patient's body and the blood vessel 20 is moved into the lumen 38 of the scope body 34.

When the desired length of blood vessel 20 has been dissected free from the surrounding connective tissue, the dissecting tool 100 is moved proximally away from the distal end of the dissected segment, and the side-biting ligation-cutting tool 250 is inserted into the proximal end of the lumen 38 and advanced distally through the lumen 38 into the area adjacent the distal end of the scope body 34 and the distal end of the dissected blood vessel 20. The side-biting ligation-cutting tool 250 is positioned such that the blood vessel 20 is between the first yoke 258 and the second yoke 260 of the ligation clip applicator 252. When the blood vessel 20 is properly positioned between yokes 258 and 260, the physician manipulates the handle 270 to actuate the ligation clip applicator 252. As the yokes 258 and 260 move toward each other, the yokes 258 and 260 act to pinch the ligation clips 266 over the distal end of the dissected blood vessel 20 (thus stopping blood flow through the blood vessel 20). While the blood vessel 20 is held securely by the ligation clip applicator 252, the physician pushes the plunger 274 to activate the cutting mechanism 254. The cutting blade 280 advances between the ligation clips 266 and through the blood vessel 20 to sever the blood vessel 20 into a freed section 360 having free end 352 (FIG. 10) and a free end 361

(FIG. 13) and a remaining section 362. When the plunger 274 is released by the physician, the cutting blade 280 returns to its retracted position. The handle 270 is manipulated to separate the prongs 262A and 262B, and the side-biting ligation-cutting tool 250 is withdrawn proximally through the lumen 38 of the endoscope 30. The tool 250 may apply ligation clips on sections 360 and 362, or just one clip on the remaining section 362 of the blood vessel 20.

The freed section 360 of the blood vessel 20 is now free of all connections to the patient's body and is substantially within the lumen 38 of the endoscope 30. While gripping the now dissected blood vessel 20 with the gripping forceps 150, the physician may simultaneously remove the scope body 34 of the endoscope 30 and the enclosed segment of blood vessel 20 from the body of the patient. After the endoscope 30 and freed section 360 of blood vessel 20 are removed from the patient, the physician closes the incision 350 in the patient's body to complete the vessel harvesting procedure. The freed section 360 of the blood vessel 20 may then be removed from the lumen 38 of the endoscope 30 and prepared for its intended end use. The vessel harvesting procedure has been accomplished with only a single small incision, yet the physician can see the entire working portion of the procedure for manipulation of the tools to accomplish dissection, ligation and severing of the freed section 360 of the blood vessel 20. This results in less trauma to the patient than was previously attainable, with a much more precise and efficient procedure, both in terms of affecting the tissue surrounding the dissected vessel, and in terms of the timing and control of the procedure by the physician.

Occasionally, it is desired to remove a continuous length of a blood vessel that is longer than the scope body of the inventive endoscope. In this instance, the physician is unable to advance the endoscope and its related tools far enough from the original small incision into the patient to harvest a segment of the desired length. If no endoscope scope body is long enough to harvest a blood vessel segment of the desired length, the physician may make a second incision in the patient adjacent that point on the blood vessel where the dissection has reached via the use of the endoscope and related tools through the first incision. This is illustrated in FIG. 14.

FIG. 14 illustrates a portion of a patient's leg. A first incision 350 has been made in the patient and the blood vessel 20 severed to create free ends 353 and 352. A portion of the desired segment of the blood vessel (to the left of the incision 350 in FIG. 14) has been dissected, ligated and clipped from the surrounding tissue and side branches 22, using the inventive endoscope and tools in a manner as discussed above. The desired segment of the blood vessel (designated as segment 400 in FIG. 14) is not severed using the side-biting ligation-cutting tool 250 through the scope body 34 of the endoscope 30. Instead, a second incision 450 is made in the patient adjacent that point where the dissection of the blood vessel 20 has reached. This second incision thus exposes that portion of the blood vessel 20 which has been dissected from the surrounding connective tissue of the patient's body (segment 400). The physician releases the free end 352 of the blood vessel 20 (which has been continually held by the gripping forceps 150) and proximally withdraws the endoscope 30 and all of its associated tools which are still in the patient's body. Working through the second incision 450, the physician then grips the exposed portion of the blood vessel 20 and pulls the dissected segment 400 of the blood vessel 20 through the second incision, in direction of arrow 455 as illustrated in FIG. 14.

Once the entire dissected segment 400 has been pulled out of the patient through the second incision 450, further dissection of the remaining portion of the blood vessel 20 within the patient can continue using the inventive tools and method. As previously described, the gripping forceps 150 is inserted through the dissecting ring 110 of the dissecting tool 100 and the assembly of the dissecting tool 100 and the gripping forceps 150 is inserted into the proximal end of the lumen 38 and advanced distally through the lumen 38. The gripping forceps 150 is again used to hold the free end 352 of the segment 400 of the blood vessel 20 during the continued procedure. The endoscope 30 and dissecting tool 100 are distally advanced over the blood vessel 20 and into the patient's body through the second incision 450. The physician then continues to dissect the blood vessel 20 away from the surrounding connective tissue with the dissecting tool 100, ligating and severing side branches 22 as they are encountered using the ligation-cutting tool 150. The suction-coagulator tool 300 is also used as necessary during continued dissection and side branch severing. This process may be repeated until the desired length of blood vessel 20 has been harvested. At this point, the side-biting ligation-cutting tool 250 is employed through the second incision 450 and endoscope 30 to sever the blood vessel 20 from the patient in the desired length. The severed blood vessel is then withdrawn, along with the endoscope 30 and any related tools remaining within the patient, from the patient through the second incision 450. The severed blood vessel is removed from the endoscope and then treated as necessary for further use. The incisions 350 and 450 are then closed up, with minimal trauma to the patient. For instance, a two-step vessel harvesting procedure such as illustrated in FIG. 14 may result in the harvesting of a vessel as long as twelve to fifteen inches, with only two separate 3 cm long incisions made in the patient's skin. The entire procedure, as conducted using the inventive endoscope and its related tools, has been conducted under direct vision or endoscopic vision by the physician and is thus much more effective, efficient and elegant than prior vessel harvesting techniques.

CONCLUSION

The present invention permits a discrete segment of a blood vessel to be harvested with only a small incision in the body of a patient (or more than one small incision if a very long segment is desired). The inventive endoscope and its unique tools eliminate the need for a full length incision along the length of the blood vessel in order to harvest a segment of the blood vessel. Use of the inventive endoscope and tools eliminates the need for a second incision at the distal end of the desired segment of the blood vessel in order to sever the desired segment from the patient's body, and also allows vessel harvesting with a relatively small incision. Proximal incisions heal easier and more readily than distal incisions in most patients, and particularly for those with poor circulation in their extremities. The illumination source and the viewing device of the inventive endoscope allow the physician to directly view the dissection in process, which results in a very precise and controlled dissection of the blood vessel. At the same time, the use of the ligation-cutting tool and the side-biting ligation-cutting tool allows the physician to control bleeding by cutting and sealing off side branches to the blood vessel and the vessel itself in a secure and permanent manner. Nothing is inserted within the blood vessel being harvested during the procedure, so vessel integrity is maintained. Accordingly, undesired trauma to the vessel being harvested and to its surrounding connective tissue is minimized.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the

art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What is claimed:

1. A method of harvesting a section of a vessel from a patient's body as living tissue for use in a different environment of the patient's body comprising:

providing an endoscope of the type having a scope body with a lumen extending longitudinally therethrough, with the lumen having a proximal end and a distal end, and means for viewing an area adjacent the distal end of the lumen, the lumen having a lateral dimension of size sufficient to accommodate the vessel and a tool for use in harvesting the vessel;

exposing a first end of the vessel section to be harvested through an incision in the patient's body;

gripping the first end with a gripping tool that has been inserted through the lumen of the endoscope; and

dissecting the vessel away from surrounding connective tissue of the patient's body with a dissecting tool inserted through the lumen of the endoscope, using the viewing means to view the dissection in process;

cutting the vessel at proximal and distal ends of the vessel section; and

removing the vessel section from the patient's body, the steps of exposing, gripping, dissecting, cutting and removing being performed in a manner that minimizes damage to the endothelium of the vessel.

2. The method of harvesting a vessel according to claim 1, including:

advancing the endoscope and the dissecting tool along the vessel until a side branch of the vessel is encountered.

3. The method of harvesting a vessel according to claim 2, including:

applying a ligation member to the branch and cutting the branch between the vessel and the ligation member with a ligating-cutting tool inserted through the lumen.

4. The method of harvesting a vessel according to claim 3, including:

repeating the advancing and applying steps until the endoscope is fully inserted or a desired length of the vessel is reached.

5. The method of harvesting a vessel according to claim 1, including:

controlling bleeding as necessary with a bleeding control tool inserted through the lumen.

6. The method of harvesting a vessel according to claim 1, including:

ligating and cutting the distal end of the vessel with a transecting tool inserted through the lumen, allowing a segment of the vessel to be removed without making a second incision in the patient's body.

7. The method of harvesting a vessel according to claim 1, including:

making a second incision in the patient's body spaced from the first incision;

exposing that portion of the vessel which has been dissected from surrounding tissue of the patient's body through the second incision in the patient's body;

gripping the exposed portion of the vessel which has been dissected and that has been inserted through the lumen of the endoscope;

advancing the endoscope over the vessel and into the patient's body through the second incision; and

continuing to dissect the vessel away from surrounding connective tissue of the patient's body with a dissecting tool inserted through the lumen of the endoscope, using the viewing means to view the continued dissection in process.

8. A method of removing a section of a vessel from a patient's body for use in a different environment comprising:

providing an endoscope of the type having a scope body with a lumen extending longitudinally therethrough, with the lumen having a proximal end and a distal end, and means for viewing an area adjacent to the distal end of the lumen, the lumen having a lateral dimension of size sufficient to accommodate that section of the vessel which is being removed and a tool for use in removing the section of the vessel;

exposing a portion of the section of the vessel to be removed through an incision in the patient's body;

gripping the exposed portion with a gripping tool that has been inserted through the lumen of the endoscope; and

dissecting the section of the vessel which is being removed from the patient's body with a dissecting tool also inserted through the lumen of the endoscope, using the viewing means to view the dissection process;

cutting the vessel at proximal and distal ends of the vessel section; and

removing the vessel section from the patient's body, the steps of exposing, gripping, dissecting, cutting and removing being performed in a manner that minimizes damage to the endothelium of the vessel.

9. The method of removing a section of a vessel according to claim 8, and further including:

removing the section of the vessel through the lumen of the endoscope.

10. The method of removing a section of a vessel according to claim 8, and further including:

advancing the endoscope and the dissecting tool along the vessel until a branch of the vessel is encountered.

11. The method of removing a section of a vessel according to claim 10, and further including:

applying a ligation member to the vessel branch and cutting the branch with a ligating-cutting tool inserted through the lumen.

12. The method of removing a section of a vessel according to claim 11, and further including:

repeating the advancing and applying steps until the endoscope is fully inserted or the desired amount of the vessel is dissected.

13. The method of removing a section of a vessel according to claim 8, and further including:

controlling bleeding as necessary with a bleeding control tool inserted through the lumen.

14. The method of claim 1 further comprising re-using the vessel section as a fluid conduit in another part of the patient's body.

15. The method of claim 8 further comprising re-using the vessel section as a fluid conduit in a human body.

16. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

making an incision over a first end of the vessel section to be harvested, the length of the incision being sufficient to accommodate at least one tool used in harvesting the vessel section but being substantially smaller than the length of the vessel section;

exposing the first end of the vessel section through the incision;

dissecting the vessel away from surrounding tissue of the patient's body until a desired length of vessel which exceeds the length of the incision has been dissected free from surrounding tissue;

severing the vessel at proximal and distal ends of the vessel section with at least one tool inserted through the incision; and

removing the vessel section through the incision, the steps of making an incision, exposing, dissecting, severing, and removing being performed in a manner that minimizes damage to the endothelium of the vessel.

17. The method of harvesting a vessel according to claim 16, including:

applying a ligation member to the vessel in a position distal to the distal end of the vessel section.

18. The method of harvesting a vessel according to claim 16, including;

controlling bleeding as necessary.

19. The method of harvesting a vessel according to claim 16, including:

applying a ligation member to a side branch of the vessel; and

severing the side branch of the vessel between the ligation member and the vessel.

20. The method of claim 16 further comprising re-using the vessel section as a fluid conduit in a human body.

21. The method of claim 16 further comprising re-using the vessel section as a fluid conduit in another part of the patient's body.

22. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

making an incision in the patient's body over a first end of the vessel section to be harvested, the length of the incision being sufficient to accommodate at least one tool used in harvesting the vessel section but being substantially smaller than the length of the vessel section;

exposing the first end of the vessel section to be harvested through the incision in the patient's body;

dissecting the vessel away from surrounding tissue of the patient's body; and

viewing the dissection of the vessel with a viewing device inserted through the incision;

severing the vessel at proximal and distal ends of the vessel section; and

removing the vessel section from the patient's body, the steps of making an incision, exposing, dissecting, viewing, severing and removing being performed in a manner that minimizes damage to the endothelium of the vessel.

23. The method of harvesting a vessel according to claim 22, including:

applying a ligation member to a side branch of the vessel; and

severing the side branch between the vessel and the ligation member.

24. The method of harvesting a vessel according to claim 23, including;

repeating the dissecting step until a desired length of the vessel section has been dissected.

25. The method of harvesting a vessel according to claim 24, including:

severing the distal end of the vessel section; and

removing the vessel section through the incision.

26. The method of harvesting a vessel according to claim 22, including;

repeating the dissecting step until a desired length of the vessel section has been dissected.

27. The method of harvesting a vessel according to claim 26, including:

severing the distal end of the vessel section; and

removing the vessel section through the incision.

28. The method of harvesting a vessel according to claim 22, including:

controlling bleeding as necessary.

29. The method of claim 20 further comprising re-using the vessel section as a fluid conduit in a human body.

30. The method of claim 22 further comprising re-using the vessel section as a fluid conduit in another part of the patient's body.

31. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

providing a device having an elongated body, the body having a lumen extending longitudinally therethrough, the lumen having a proximal end and a distal end and having a lateral dimension of size sufficient to accommodate the vessel and a tool for use in harvesting the vessel;

exposing a first end of the vessel section to be harvested through an incision in the patient's body;

gripping the first end with a gripping tool that has been inserted through the lumen of the elongated body;

dissecting the vessel away from surrounding tissue of the patient's body with a dissecting tool inserted through the incision; and

viewing the dissection of the vessel from an area adjacent the distal end of the lumen of the elongated body;

severing the vessel at proximal and distal ends of the vessel section; and

removing the vessel section from the patient's body, the steps of exposing, gripping, dissecting, viewing, severing and removing being performed in a manner that minimizes damage to the endothelium of the vessel.

32. The method of harvesting a vessel according to claim 31, including:

advancing the elongated body and the dissecting tool along the vessel until a side branch of the vessel is encountered.

33. The method of harvesting a vessel according to claim 32, including:

applying a ligation member to the branch and cutting the branch between the vessel and the ligation member with a ligating-cutting tool inserted through the lumen.

34. The method of harvesting a vessel according to claim 33, including:

repeating the advancing and applying steps until the elongated body is fully inserted or a desired length of the vessel is reached.

35. The method of harvesting a vessel according to claim 31, including:

controlling bleeding as necessary with a bleeding control tube inserted through the lumen.

36. The method of harvesting a vessel according to claim 31, including:

ligating and cutting the distal end of the vessel with a transecting tool inserted through the lumen, allowing the vessel section to be removed without making a second incision in the patient's body.

37. The method of harvesting a vessel according to claim 31, including:

making a second incision in the patient's body spaced from the first incision;

exposing that portion of the vessel which has been dissected from surrounding tissue of the patient's body through the second incision in the patient's body;

gripping the exposed portion of the vessel which has been dissected with a gripping tool that has been inserted through the lumen of the elongated body;

advancing the elongated body over the vessel and into the patient's body through the second incision; and

continuing to dissect the vessel away from surrounding tissue of the patient's body with a dissecting tool inserted through the second incision.

38. The method of claim 31 further comprising re-using the vessel section as a fluid conduit in a human body.

39. The method of claim 3 further comprising re-using the vessel section as a fluid conduit in another part of the patient's body.

40. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

making an incision over a first end of the vessel section to be harvested, the length of the incision being sufficient to accommodate at least one tool used in harvesting the vessel section but being substantially smaller than the length of the vessel section;

exposing the first end of the vessel section through the incision;

dissecting the vessel away from surrounding tissue of the patient's body with a dissecting tool inserted through the incision until a desired length of vessel which exceeds the length of the incision has been dissected free from surrounding tissue;

viewing the dissection of the vessel with a viewing device inserted through the incision;

severing the vessel at proximal and distal ends of the vessel; and

removing the vessel section from the patient's body, the steps of making an incision, exposing, dissecting, viewing, severing, and removing being performed in a manner that minimizes damage to the endothelium of the vessel.

41. The method of claim 40 further comprising re-using the vessel section as a fluid conduit in a human body.

42. The method of claim 40 further comprising re-using the vessel section as a fluid conduit in another part of the patient's body.

43. The method of harvesting a vessel according to claim 40, including:

applying a ligation member to the vessel in a position distal to the distal end of the vessel section.

44. The method of harvesting a vessel according to claim 40, including;

controlling bleeding as necessary.

45. The method of harvesting a vessel according to claim 40, including:

litigating a branch of the vessel; and

severing the branch of the vessel between the ligation and the vessel.

46. The method of harvesting a vessel according to claim 40 including maintaining the lumen of the vessel clear of any tools and other objects used in the harvesting procedure.

47. The method of harvesting a vessel according to claim 40 including making a second incision in the patient's body spaced from the first incision, the second incision being substantially smaller than the length of the vessel section, and wherein the vessel section is removed through the second incision.

48. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

making an incision over a first end of the vessel section to be harvested, the length of the incision being sufficient to accommodate at least one tool used in harvesting the vessel section but being substantially smaller than the length of the vessel section;

exposing the first end of the vessel section through the incision;

dissecting the vessel away from surrounding tissue of the patient's body until a desired length of vessel which exceeds the length of the incision has been dissected free from surrounding tissue;

severing the vessel at proximal and distal ends of the vessel section with at least one tool inserted through the incision;

removing the vessel section through the incision; and

re-using the vessel section as a fluid conduit in a human body.

49. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

making an incision in the patient's body over a first end of the vessel section to be harvested, the length of the incision being sufficient to accommodate at least one tool used in harvesting the vessel section but being substantially smaller than the length of the vessel section;

exposing the first end of the vessel section to be harvested through the incision in the patient's body;

dissecting the vessel away from surrounding tissue of the patient's body; and

viewing the dissection of the vessel with a viewing device inserted through the incision;

severing the vessel at proximal and distal ends of the vessel section;

removing the vessel section from the patient's body; and

re-using the vessel section as a fluid conduit in a human body.

50. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

providing a device having an elongated body, the body having a lumen extending longitudinally therethrough, the lumen having a proximal end and a distal end and having a lateral dimension of size sufficient to accommodate the vessel and a tool for use in harvesting the vessel;

exposing a first end of the vessel section to be harvested through an incision in the patient's body;

gripping the first end with a gripping tool that has been inserted through the lumen of the elongated body;

dissecting the vessel away from surrounding tissue of the patient's body with a dissecting tool inserted through the incision; and

viewing the dissection of the vessel from an area adjacent the distal end of the lumen of the elongated body;

severing the vessel at proximal and distal ends of the vessel section;

removing the vessel section from the patient's body; and

re-using the vessel section as a fluid conduit in a human body.

51. A method of harvesting a section of a vessel from a patient's body for use in a different environment comprising:

making an incision over a first end of the vessel section to be harvested, the length of the incision being sufficient to accommodate at least one tool used in harvesting the vessel section but being substantially smaller than the length of the vessel section;

exposing the first end of the vessel section through the incision;

dissecting the vessel away from surrounding tissue of the patient's body with a dissecting tool inserted through the incision until a desired length of vessel which exceeds the length of the incision has been dissected free from surrounding tissue;

viewing the dissection of the vessel with a viewing device inserted through the incision;

severing the vessel at proximal and distal ends of the vessel;

removing the vessel section from the patient's body; and

re-using the vessel section as a fluid conduit in a human body.

52. A method of re-using a section of a vessel from a patient's body in the patient's body comprising:

making an incision over a first end of the vessel section, the length of the incision being sufficient to accommodate at least one tool used in the method but being substantially smaller than the length of the vessel section;

exposing the first end of the vessel section through the incision;

dissecting the vessel away from surrounding tissue of the patient's body with a tool inserted through the incision until a desired length of vessel which exceeds the length of the incision has been dissected free from surrounding tissue;

severing the first end of the vessel section with a tool inserted through the incision; and

re-using the vessel section as a fluid conduit in the patient's body.

* * * * *

EXHIBIT B

US006830546B1

(12) **United States Patent**
Chin et al.

(10) **Patent No.: US 6,830,546 B1**
(45) **Date of Patent: Dec. 14, 2004**

(54) **DEVICE AND METHOD FOR REMOTE VESSEL LIGATION**

(75) Inventors: **Albert K. Chin**, Palo Alto, CA (US); **Edwin J. Hlavka**, Palo Alto, CA (US); **John P. Lunsford**, San Carlos, CA (US); **Jeffrey W. Baxter**, San Jose, CA (US)

(73) Assignee: **Origin Medsystems, Inc.**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 130 days.

(21) Appl. No.: **10/052,016**

(22) Filed: **Jan. 16, 2002**

Related U.S. Application Data

(63) Continuation of application No. 09/521,279, filed on Mar. 7, 2000, now Pat. No. 6,348,037, which is a continuation of application No. 09/200,218, filed on Nov. 25, 1998, now Pat. No. 6,162,173, which is a continuation-in-part of application No. 09/102,723, filed on Jun. 22, 1998, now Pat. No. 5,895,353.

(51) **Int. Cl.**[7] **A61B 17/02**
(52) **U.S. Cl.** **600/206**; 600/235
(58) **Field of Search** 606/204, 205, 606/206, 201, 210, 235, 159

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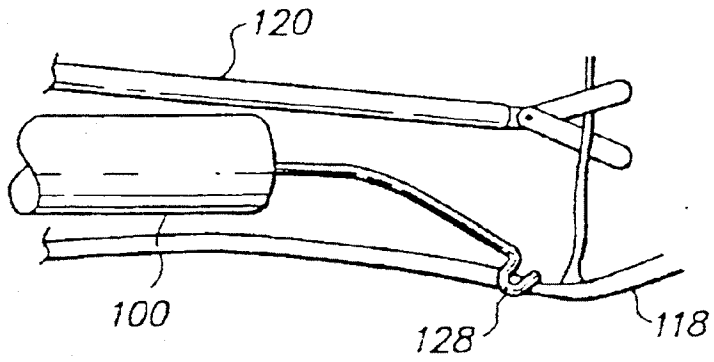
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Primary Examiner—Cary E. O'Connor
(74) *Attorney, Agent, or Firm*—Fenwick & West LLP

(57) **ABSTRACT**

A retractor and a surgical tool are positioned at the distal end of the cannula. A dissection cradle is located at the distal end of a distal portion of the retractor that is resiliently skewed relative to the cannula axis, and includes two substantially parallel, spaced legs with the retractor shaped in a loop therebetween. The procedure includes locating a vessel and side branch of interest and extending the retractor to retain the vessel in the dissection cradle to urge the vessel away from the axis of the cannula in order to isolate a side branch for exposure to the surgical tool.

9 Claims, 13 Drawing Sheets



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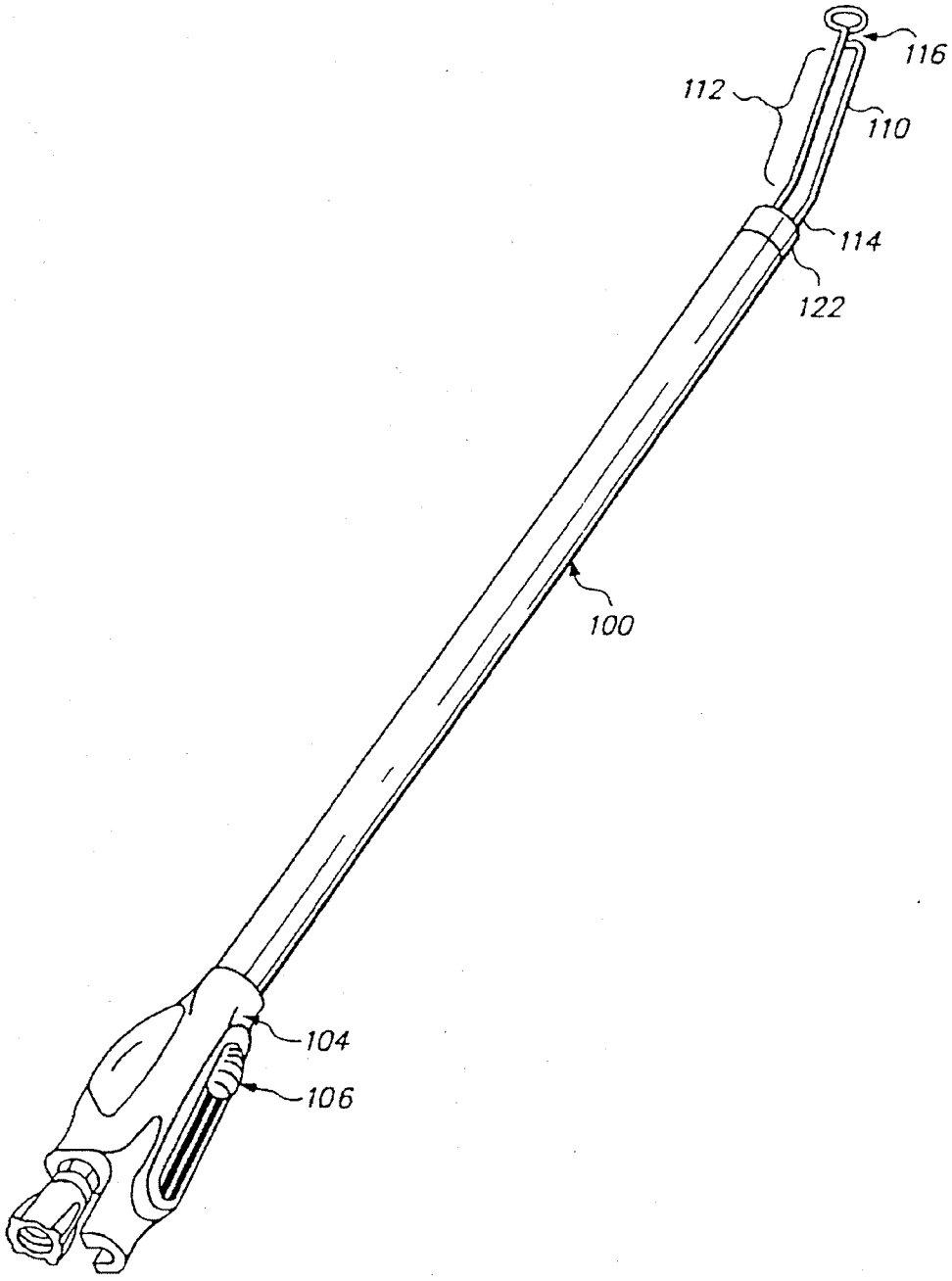


FIG. 1

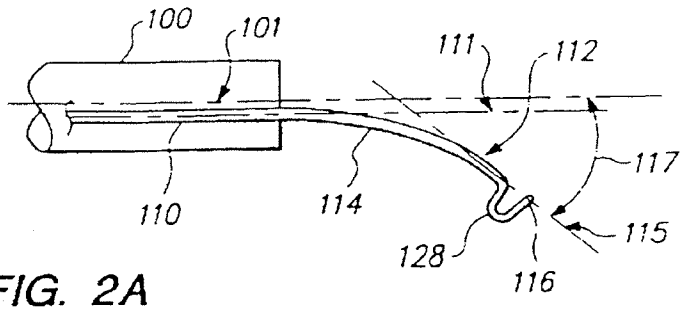


FIG. 2A

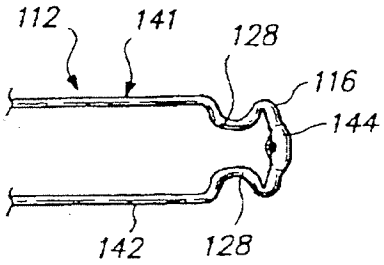


FIG. 2B

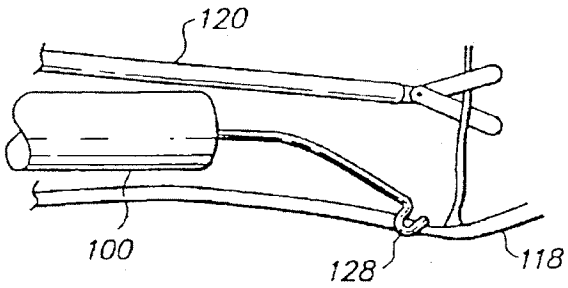


FIG. 3A

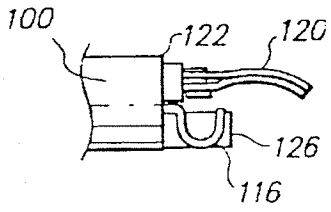


FIG. 3B

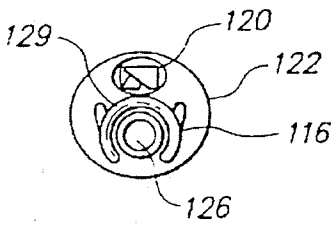


FIG. 3C

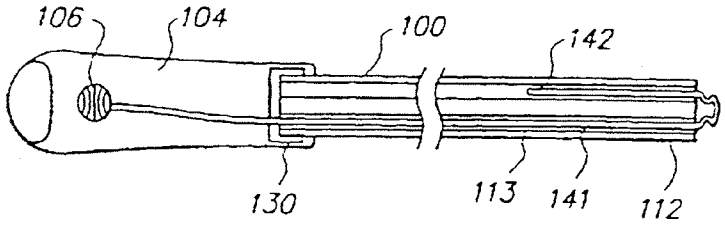


FIG. 4A

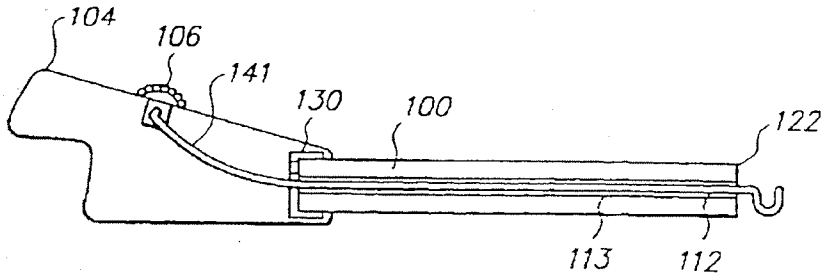


FIG. 4B

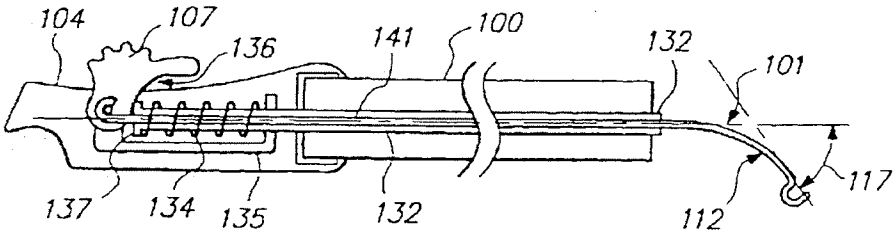


FIG. 5A

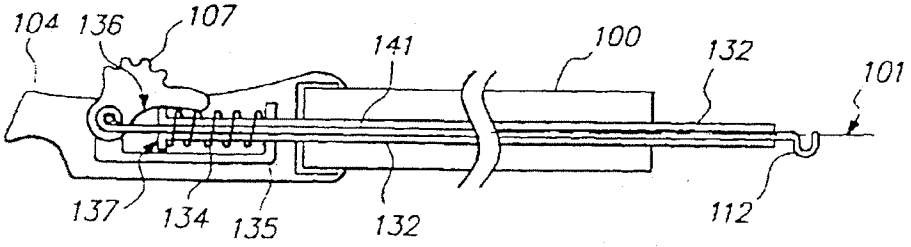


FIG. 5B

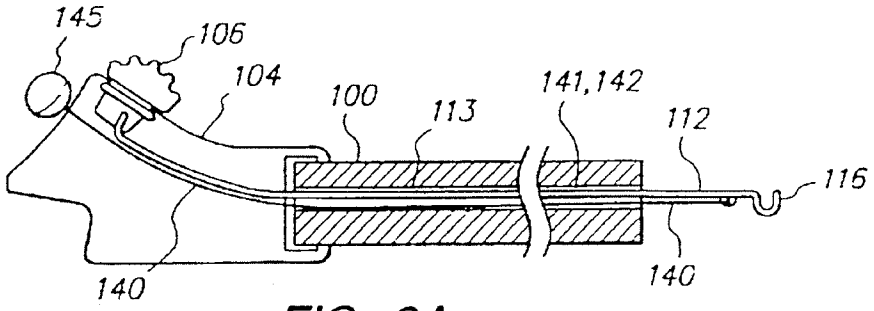


FIG. 6A

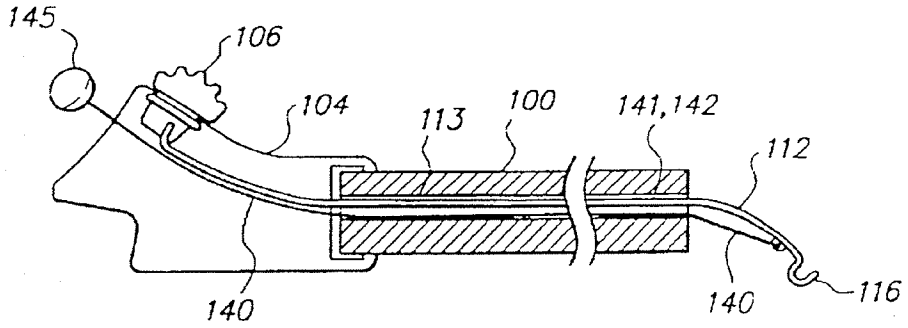


FIG. 6B

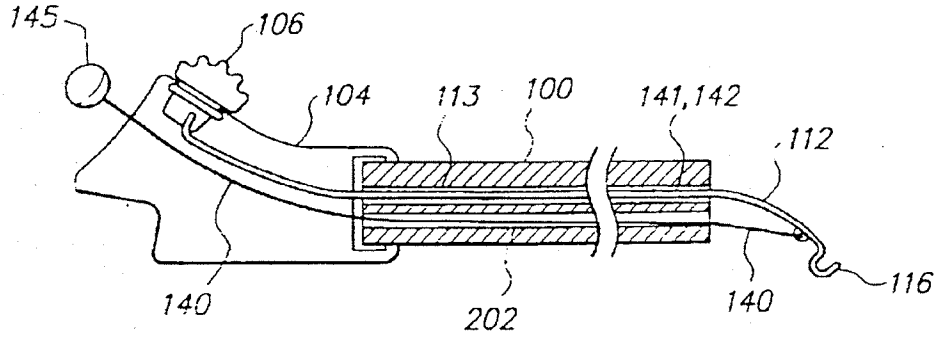


FIG. 6C

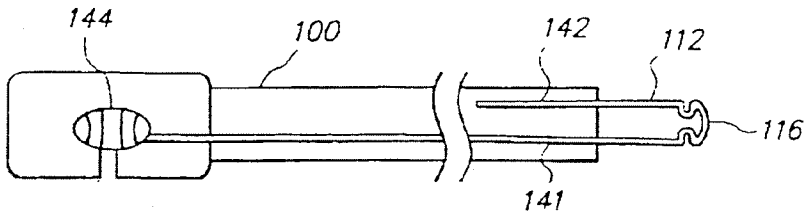


FIG. 7A

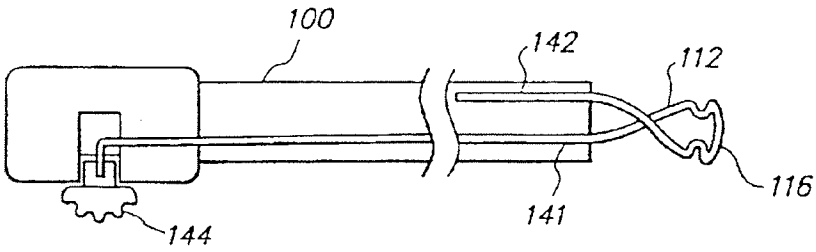


FIG. 7C

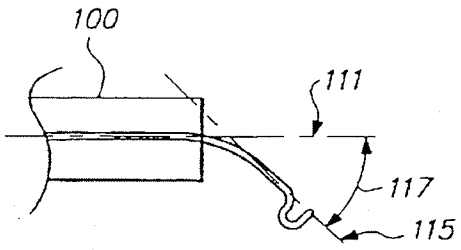


FIG. 7B

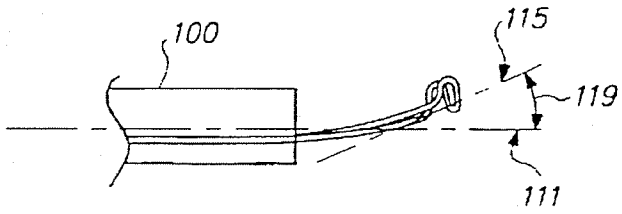


FIG. 7D

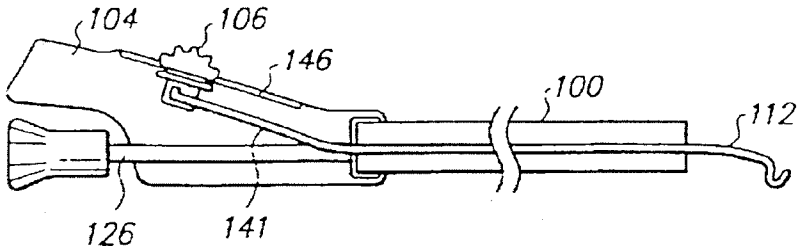


FIG. 8A

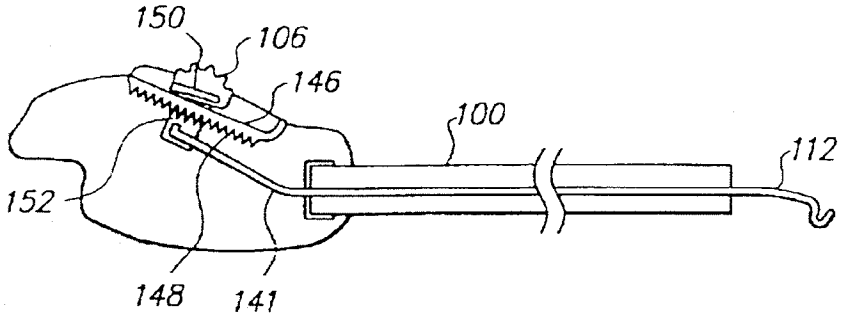


FIG. 8B

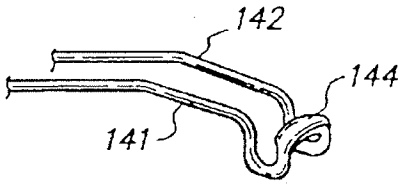


FIG. 9A

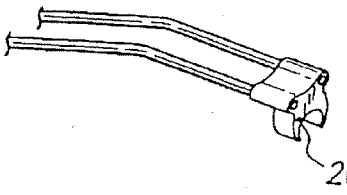


FIG. 9B



FIG. 9C

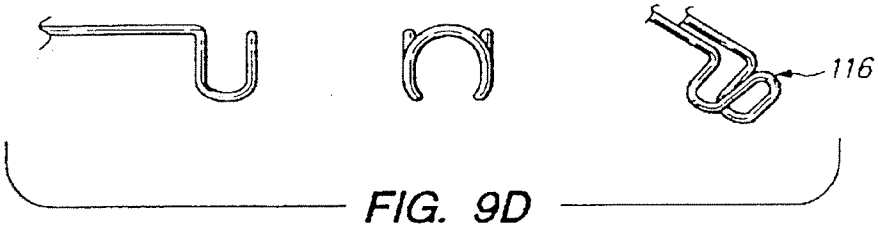


FIG. 9D

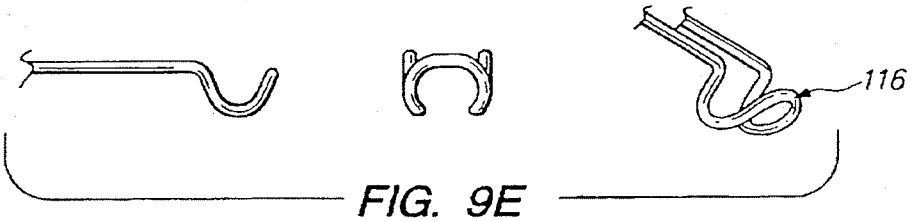


FIG. 9E

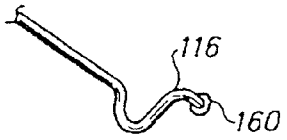


FIG. 9F

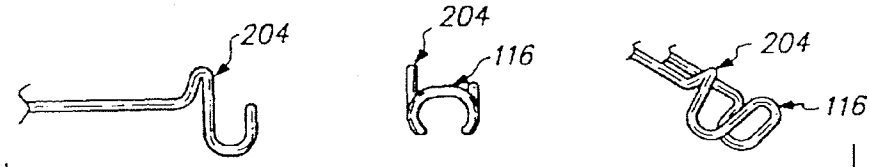


FIG. 9G

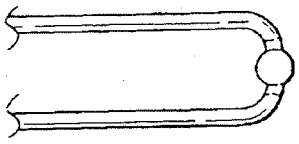


FIG. 10A



FIG. 10B

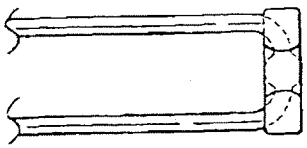


FIG. 10C

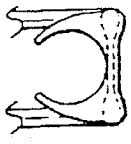


FIG. 10D

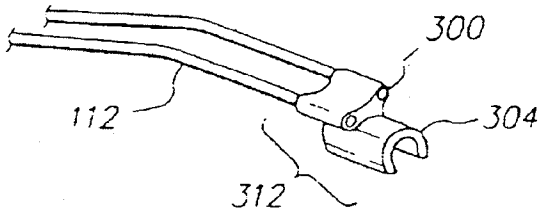


FIG. 11

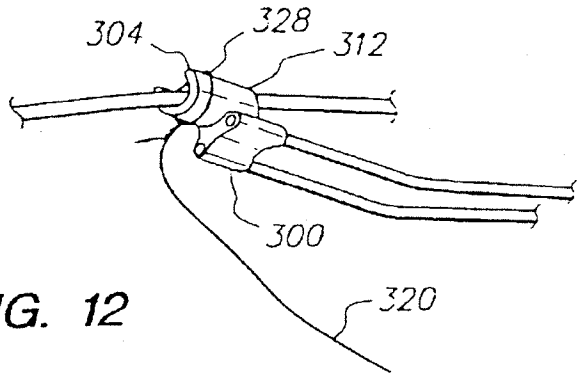


FIG. 12

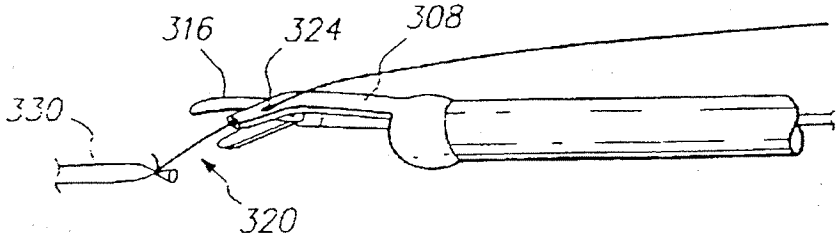


FIG. 15

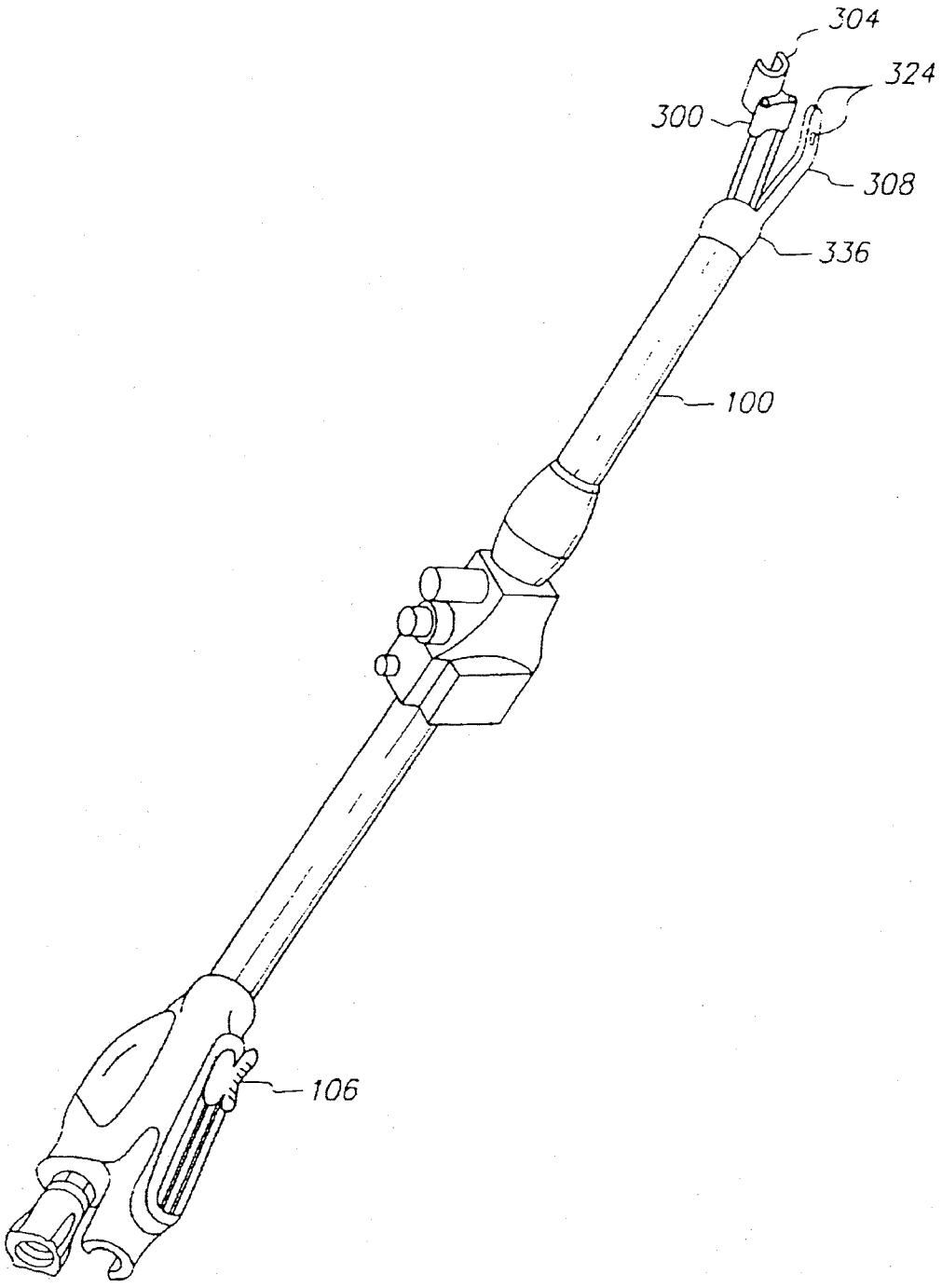


FIG. 13

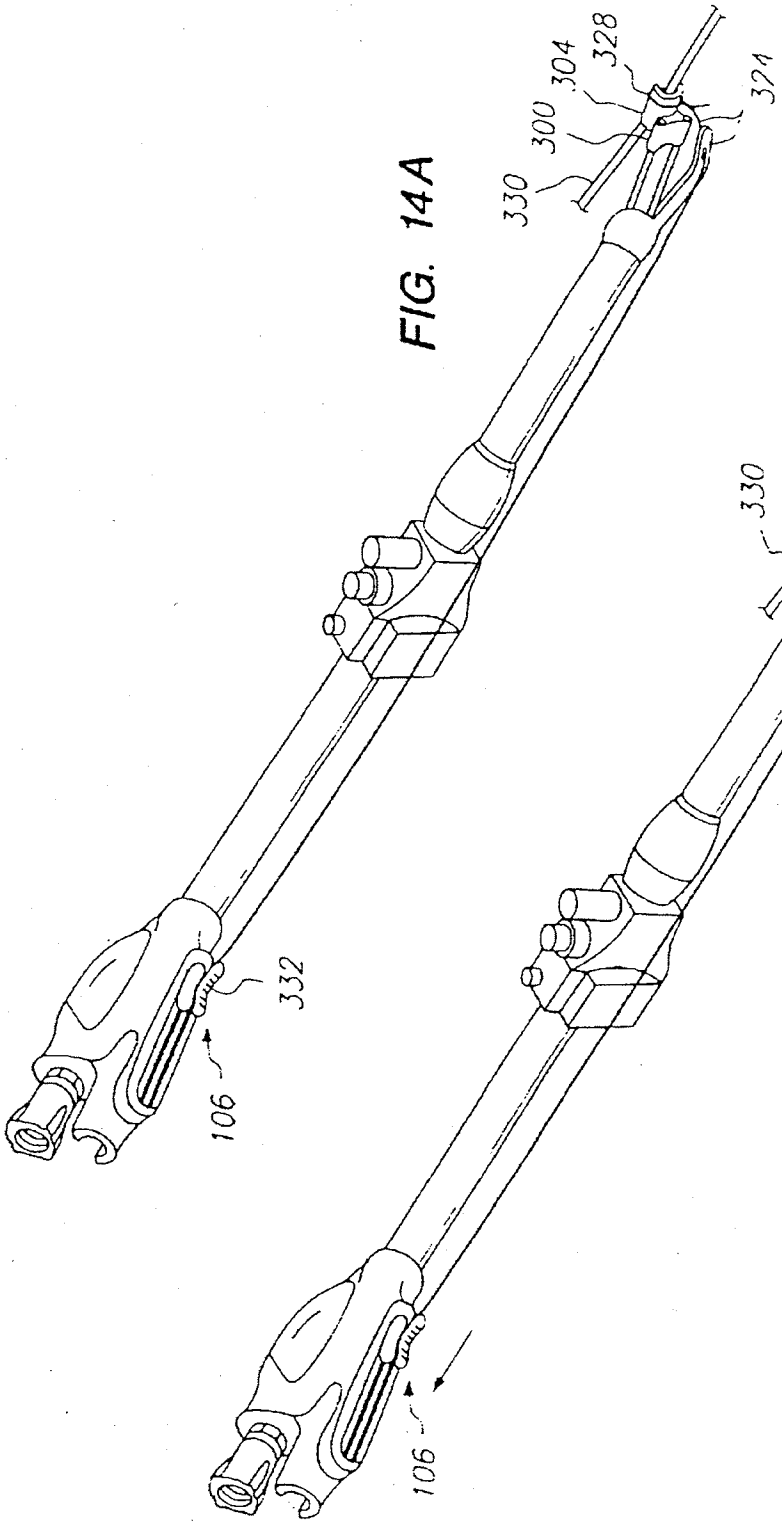


FIG. 14A

FIG. 14B

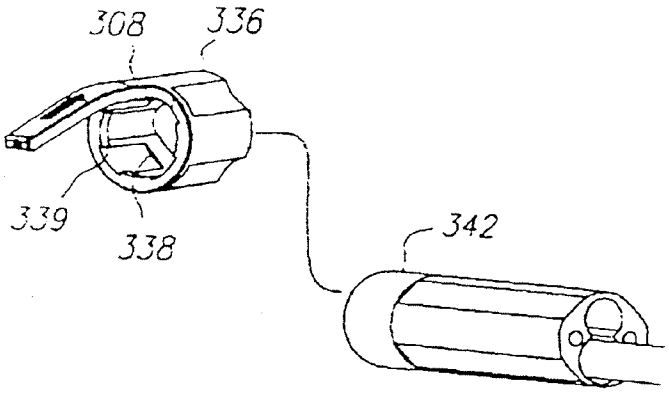


FIG. 16A

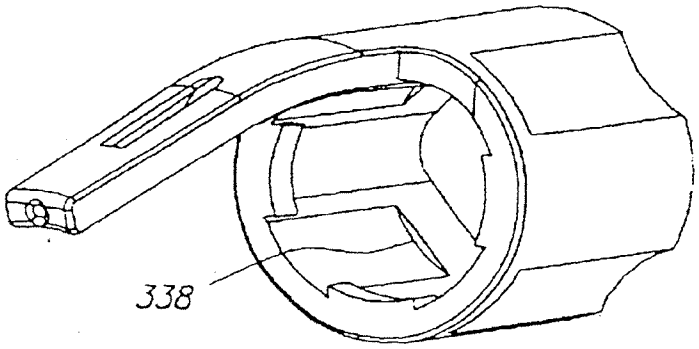


FIG. 16B

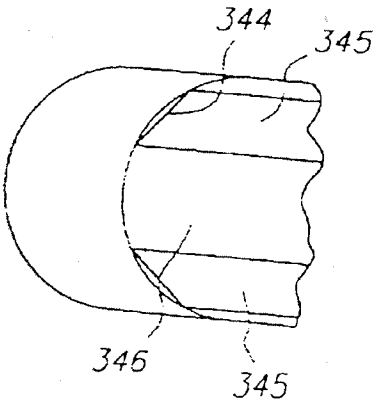


FIG. 16C

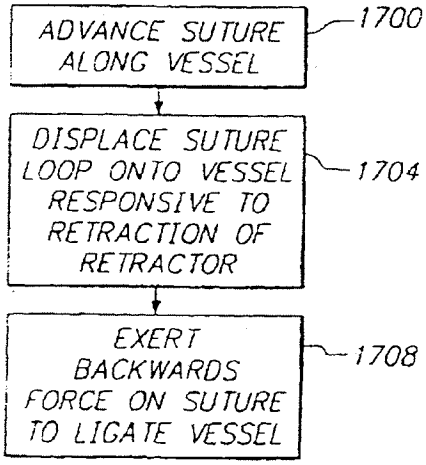

ADVANCE SUTURE ALONG VESSEL
1700
DISPLACE SUTURE LOOP ONTO VESSEL RESPONSIVE TO RETRACTION OF RETRACTOR
1704
EXERT BACKWARDS FORCE ON SUTURE TO LIGATE VESSEL
1708

FIG. 17

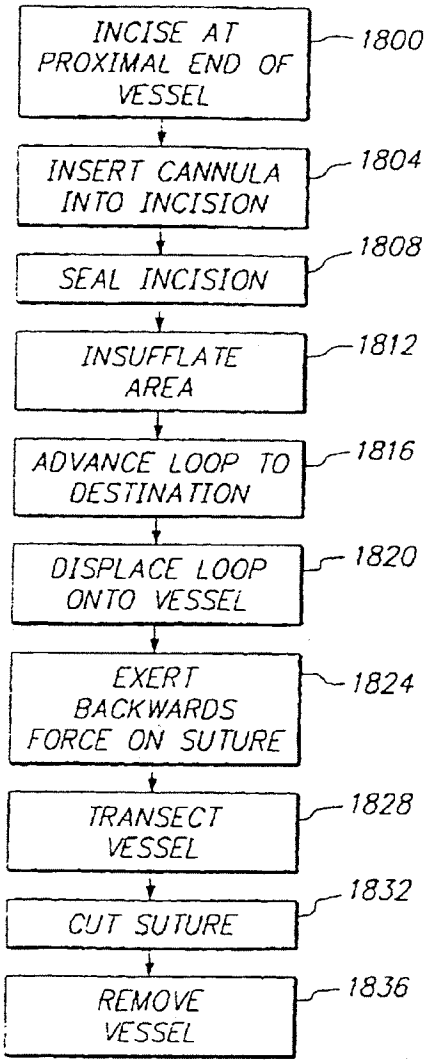

INCISE AT PROXIMAL END OF VESSEL
1800
INSERT CANNULA INTO INCISION
1804
SEAL INCISION
1808
INSUFFLATE AREA
1812
ADVANCE LOOP TO DESTINATION
1816
DISPLACE LOOP ONTO VESSEL
1820
EXERT BACKWARDS FORCE ON SUTURE
1824
TRANSECT VESSEL
1828
CUT SUTURE
1832
REMOVE VESSEL
1836

FIG. 18

DEVICE AND METHOD FOR REMOTE VESSEL LIGATION

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of application Ser. No. 09/521,279 filed on Mar. 7, 200, now U.S. Pat. No. 6,348,037 which is a continuation of application Ser. No. 09/200,218 filed on Nov. 25, 1998, now U.S. Pat. No. 6,162,173, and a continuation-in-part application of application Ser. No. 09/102,723 filed on Jun. 22, 1998 now U.S. Pat. No. 5,895,353, which are incorporated herein in their entirety.

FIELD OF THE INVENTION

This invention relates to a cannula used for vessel retraction, and more particularly to a cannula and method that includes an endoscopic retractor for vessel ligation.

BACKGROUND OF THE INVENTION

Certain cannulas have surgical tools located within the cannula for performing surgical operations on a vessel of interest. The cannula is inserted into a surgical site with the distal end of the cannula positioned near the vessel of interest. An endoscope positioned within the cannula allows the surgeon to view the target area, and allows the surgeon to position the surgical tool correctly. One common procedure is to ligate a vessel or other tissue by tightening a suture loop tied as a slipknot on the vessel before transection to provide hemostasis to the vessel.

However, surgeons encounter several difficulties in ligation procedures. In one ligation procedure, a second incision must be made at the opposite end of the vessel of interest to ligate and transect the vessel. Multiple incisions are invasive and should be minimized if possible. In order to avoid this second incision, some conventional methods require tying a suture loop around the vessel, and pushing the loop along the vessel with a knot pusher until the opposite end is reached. Then, the loop is tightened to provide ligation. However, this procedure is difficult because the slipknot often catches on stumps of cut tributaries or other tissue, and then constricts around the vessel at the wrong position. Also, there is no easy method for transecting the vessel after the suture loop is tied to the vessel without potentially prematurely severing the suture.

Thus, a device and method is needed to allow remote, one-incision, ligation of a vessel which allows a suture loop to be moved reliably to the site of interest, and ensures that the transection instrument is able to transect the vessel, and cut the suture.

SUMMARY OF THE INVENTION

In accordance with the present invention, a retractor is positioned within a cannula with a dissection cradle end of the retractor positioned at the distal end of the cannula. The retractor includes a first portion that has an axis approximately parallel to a central axis of the cannula, and a second portion that has an axis which is at an angle with respect to the central axis of the cannula. The dissection cradle is located at the distal end of the second portion of the retractor. In another embodiment, the retractor includes two legs having substantially parallel axes that selectively protrude from the distal end of the cannula. The protruding legs support the dissection cradle formed in the shape of a loop that is positioned in a plane skewed relative to the axes of the legs, with a bottom of the loop directed away from the cannula. Thus, in operation, when the surgeon locates a vein and side branch of interest, the surgeon extends the retractor to cradle the vein in the dissection cradle. Once cradled, the retractor may be fully extended, pulling the vein away from the axis of the cannula, causing the side branch to be isolated and exposed to a surgical tool. The surgical tool may then be extended from within the cannula to operate on the isolated and exposed side branch.

In another embodiment, the top of the loop of the dissection cradle is flat and thin, allowing atraumatic support of the vein, and minimizing contact between the retractor and the surgical tool. In yet a further embodiment, the retractor includes a single leg with the loop formed by the one leg of the retractor, and with a stopper coupled to the distal end of the retractor. In still another embodiment, the cannula comprises a sliding tube which encases the retractor, and in a first position is extended out to encase the second portion of the retractor, and in a second position is extended to encase only the first portion of the retractor. In response to being in the first position, the second and first portions of the retractor are both approximately parallel to the axis of the cannula. In the second position, the second portion of the retractor is skewed relative to the axis of the cannula.

In accordance with an alternate embodiment of the present invention, a retractor is positioned within a cannula with a dissection cradle end of the retractor positioned at the distal end of the cannula. The dissection cradle comprises a shoulder part and a curved channel part. Suture forming a suture loop is threaded through a hole in a tension mount that is fixed to the distal end of the cannula and is abutted against the distal end of the shoulder. Upon advancement to the surgical site of interest, the suture loop is safely maintained in place due to the tension provided by the tension mount and the support provided by the shoulder. The curved channel provides a groove in which the vessel of interest may be cradled. Upon retraction of the retractor, the suture loop is displaced onto the vessel at the desired position for ligation. In one embodiment, the loop is tightened by detaching the proximal end of the suture from the cannula and pulling on the suture, constricting the suture loop. In an alternate embodiment, a manual controller for retracting the retractor is attached to the proximal end of the suture. Upon slidable retraction of the manual controller, the retractor is retracted, the loop is displaced onto the vessel, and the loop is tightened.

In a further embodiment, a transecting device is positioned within the cannula. The distal end of the tension mount is positioned to allow the distal end to be proximal to the shoulder of the dissection cradle responsive to the shoulder being in an axial position relative to the tension mount. This results in the suture and vessel being reliably positioned within reach of the transecting device for transection of the vessel and cutting of the suture.

Finally, in a preferred embodiment, the retractor has a distal end having an axis skewed relative to the central axis of the cannula, thus facilitating accurate positioning of the vessel and suture for transection and cutting, and ensuring the proper displacement of the suture loop onto the vessel in response to the retraction of the retractor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a preferred embodiment of cannula **100** showing retractor **112** in an extended position.

FIG. **2***a* is a cut-away side view of retractor **112** and cannula **100**.

FIG. 2*b* is a top view of retractor **112**.

FIG. 3*a* is a perspective side view of cannula **100** with a saphenous vein positioned within the cradle **116**.

FIG. 3*b* is a perspective side view of the distal end **122** of cannula **100** in an embodiment in which an endoscope **126** and a surgical tool **120** are present and partially extended.

FIG. 3*c* is a front view of the distal end **122** of cannula **100** in which the surgical tool **120** and the retractor **116** are partially extended, and an endoscope **126** is present.

FIG. 4*a* is a cut-away top view of cannula **100**.

FIG. 4*b* is a cut-away side view of cannula **100**.

FIG. 5*a* is a cut-away view of a sliding tube embodiment of cannula **100** in a first position.

FIG. 5*b* is a cut-away view of the sliding tube embodiment of FIG. 5*a* in a second position.

FIG. 6*a* is a cut-away view of an embodiment of cannula **100** having an angling device **140**.

FIG. 6*b* is a cut-away side view of the apparatus illustrated in FIG. 6*a* in which the retractor **112** is extended and the angling device **140** is actuated.

FIG. 6*c* is a cut-away side view of the angling device embodiment in which the angling device **140** is in a separate lumen from the retractor **112**.

FIG. 7*a* is a cut-away side view of a twistable retractor **112** in a straight position.

FIG. 7*b* is a side view of the retractor **112** of FIG. 7*a*.

FIG. 7*c* is a cut-away side view of twistable retractor **112** in a crossed position.

FIG. 7*d* is a side view of the retractor **112** of FIG. 7*c*.

FIG. 8*a* is a cut-away side view of the handle **104**.

FIG. 8*b* is a cut-away side view of an alternate embodiment of handle **104**.

FIG. 9*a* is a side view of cradle **116**.

FIG. 9*b* illustrates a first alternate embodiment of cradle **116**.

FIG. 9*c* illustrates multiple views of a second alternate embodiment of cradle **116**.

FIG. 9*d* illustrates multiple views of a third alternate embodiment of cradle **116**.

FIG. 9*e* illustrates multiple views of a fourth alternate embodiment of cradle **116**.

FIG. 9*f* illustrates multiple views of a fifth alternate embodiment of cradle **116**.

FIG. 9*g* illustrates multiple views of an embodiment of cradle **116** having a spur.

FIG. **10***a* illustrates a top view of an embodiment of the cradle **116** of FIG. 9*c* without a "C" ring.

FIG. **10***b* illustrates a side view of the cradle **116** of FIG. **10***a*.

FIG. **10***c* illustrates a top view of the cradle **116** of FIG. 9*c* with the "C" ring attached.

FIG. **10***d*

illustrates a side view of the cradle **116** of FIG. **10***c*.

FIG. **11** illustrates a perspective side view of cradle **312** for remotely ligating vessel.

FIG. **12** illustrates a perspective side view of cradle **312** in operation.

FIG. **13** illustrates a perspective side view of cannula **100** having a dissection cradle **312**.

FIG. **14***a* illustrates a perspective side view of cannula **100** with retractor **112** extended.

FIG. **14***b* illustrates a perspective side view of cannula **100** with a retractor **112** retracted.

FIG. **15** illustrates a perspective side view of cannula **100** with transection device **316**.

FIGS. **16***a–c* illustrates multiple views of tension mount **308**.

FIG. **17** is a flowchart illustrating the process of remote ligation of a vessel in accordance with the present invention.

FIG. **18** is a flowchart illustrating the process of remote ligation and vessel harvestation under gas insufflation.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates a perspective view of a preferred embodiment of cannula **100** showing retractor **112** in an extended position. Cannula **100** includes an outer housing of bioinert material such as polymed UD that may be approximately 12" to 18" in length. The proximal end of the cannula **100** is disposed in handle **104** that includes a button **106** which is coupled to retractor **112** for controlling the translational movement of retractor **112**, as described in more detail below.

The distal end of the cannula houses a retractor **112**, and optionally an endoscope **126** and a surgical tool **120**, described below. FIG. 2*a* illustrates the retractor **112** in more detail. In one embodiment, retractor **112** is formed of resilient wire which has a smooth bend intermediate to a first portion **110** and a second portion **114** of the retractor. The retractor **112** is described as having two portions for ease of description, although the retractor **112** may be formed as an integrated structure. However, retractor **112** may also be manufactured from two separate portions **110**, **114** that are coupled together. The first portion **110** of the retractor **112** is positioned within the cannula **100** with the axis **111** of the first portion **110** approximately parallel to the axis **101** of the cannula **100**. The second portion **114** is positioned to bend away from the central axis **101** of the cannula. The angle **117** of displacement between the axis **115** of the second portion and the central axis **101** of cannula **100** may be any angle from zero to 180 degrees. The second portion **114** includes a dissection cradle **116** at the distal end of the second portion **114**. The retractor **112** may be formed of bioinert material such as stainless steel, or a polymer such as nylon or polyetherimide, or other appropriately strong and springy plastic. In one embodiment, the retractor **112** includes a coating for lubrication, insulation, and low visual glare using, for example, parylene or nylon **11**.

FIG. 2*b* illustrates the retractor **112** formed with two legs. The legs **141**, **142** of the retractor **112** at the distal end form the dissection cradle **116** in a loop or "U" shape, as shown in FIG. 2*a*. The top portion **144** of the U-shaped bend is preferably flattened to provide additional surface area for atraumatically supporting a vein **118** or vessel of interest. The side arches **128** of the dissection cradle **116** are used for skeletonizing or dissecting the vein from the surrounding tissues, as well as acting as walls to keep the vessel captured within the arch. The several embodiments of dissection cradle **116** are described in more detail below.

FIG. 3*a* illustrates a perspective view of the cannula **100** in accordance with the present invention with the retractor fully extended, holding a saphenous vein **118**, and also illustrates an external surgical tool **120** disposed adjacent the cannula **100** for performing a surgical operation, for example, severing a tributary or side branch of the vein **118**. The vein is positioned within the side arches **128** of the cradle **116**. The dissection cradle **116** may be used to cradle

a vein, vessel, tissue or organ of interest, and surgical tool **120** may be any surgical tool suitable for performing a surgical procedure near the dissection cradle **116**.

FIG. 3*b* illustrates a perspective view of cannula **100** in an embodiment in which the surgical tool **120** is positioned within the cannula **100**, and an endoscope **126** is present. In this embodiment, cradle **116** preferably overlays the endoscope **126** with sufficient clearance to facilitate relative movements thereof. However, the endoscope may also be located adjacent the surgical tool **120**. In one embodiment, endoscope **126** is positioned with cannula **100** to allow a clear field of view upon extension of the retractor **112**. Surgical tool **120** is illustrated as scissors, used to sever a tributary or side branch of a saphenous vein **118**. In this embodiment, surgical tool **120** is maximally displaced from the cradle **116** at the cannula end **122**. More specifically, as shown in FIG. 3*c*, the "U"-shaped loop **129** of the cradle **116** is closest to the surgical tool **120**. This ensures that a vein **118** or other tissue of interest is retracted away from the surgical tool **120** to facilitate manipulating the surgical tool **120** relative to the side branch or other tissue.

FIG. 4*a* is a cut-away top view of cannula **100**. The retractor **112** is slidably positioned within minor lumens **113** along the length of the cannula **100** within close tolerances in order to position the retractor **112** stably within the cannula **100**. For example, in one embodiment retractor legs **141**, **142** are approximately 0.045 inches in diameter and the lumens **113** encasing the legs **141**, **142** are approximately 0.080 inches in diameter, as friction between the legs of the retractor **112** and the lumens **113** holds the retractor stably within the cannula. This configuration restricts rotational movement of the retractor to provide more stable retraction as compared with conventional retractors. The legs **141**, **142** of the retractor **112** are formed of flexible, resilient material and are retained within the lumen **113** in substantially straight or flat orientation, but may return to a material bend or curve, as illustrated in FIG. 5*a*, as the retractor **112** is extended from the distal end of the cannula **100**.

The leg **141** of the retractor **112** passes through a sliding gas or fluid seal **130** at the proximal end of the lumen **113**. The leg **141** of the retractor **112** passes out of the cannula **100** and into handle **104** for attachment to a slider button **106** for facilitating translational movement of the retractor **112** from the proximal or handle end of the cannula **100**. However, other types of control devices such as knobs, grips, finger pads, and the like may be linked in conventional ways to the retractor **112** in order to manually control the translational movement of retractor **112**. In one configuration, the proximal end of leg **141** is bent relative to the axis of the cannula, and the button **106** is attached to the bent position of the leg **141** to facilitate moving the button **106** and the retractor **112** translationally under manual control. The button **106** preferably includes lateral grooves to prevent finger or thumb slippage during sliding manipulation of the retractor **112**.

Thus, in the operation of a preferred embodiment, a user actuates the slider button **106** to extend retractor **112** out of the lumen **113** at the distal end of the cannula **100**. In one embodiment, the resilient retractor **112** is formed in a smooth bend, as shown in FIG. 2*a*, and gradually deflects away from the central axis **101** of the cannula **100** as the retractor is extended. Upon encountering the target vessel or tissue of interest, the vessel is restrained in the cradle **116**, and a lateral resilient force is exerted on the target vessel in a direction away from the cannula. The vessel is thus pushed away from the axis of the cannula **100**, isolating it from surrounding tissue or adjacent vessels such as tributaries or side branches. As a tributary is thus isolated, a surgical tool **120** such as cauterizing scissors may be safely employed to operate on the tributary without harming the saphenous vein **118**. When retracted into the cannula **100**, the retractor **112** is again resiliently straightened or flattened.

In an alternate embodiment as illustrated in FIGS. 5*a* and 5*b*, a sliding tube **132** is added to provide operational versatility to cannula **100**. In a first position, the sliding tube **132** is retracted and the retractor **112** protrudes from the distal end at an angle with respect to the central axis **101** of the cannula **100**. In a second position, the sliding tube **132** is extended out, temporarily straightening the retractor **112**. As illustrated in FIG. 5*a*, a sliding tube **132**, in a first position encases the retractor **112** up to the point at which the retractor **112** curves away from the central axis **101** of the cannula thus allowing the retractor **112** to displace and isolate a target vessel. The proximal end of the sliding tube **132** is linked to button **107** for translationally moving retractor **112** as well as actuating the sliding tube **132**. In one embodiment, as illustrated in FIG. 5*a*, the sliding tube **132** is in a first position with the button **107** in an upright position. A spring **134** is coupled between a support structure **135** and the proximal end **137** of the sliding tube **132**. In the first position of sliding tube **132**, the spring **134** is extended fully and exerts little or no force on the sliding tube **132**. Of course, sliding tube **132** may be manually manipulated without linkage to a button **107**.

To extend the sliding tube **100**, button **107** is pushed down. As illustrated in FIG. 5*b*, the button **107** has a cam surface **136** which pushes on the proximal end **137** of the sliding tube **132** as the button **107** is pressed. The sliding tube **132** is pushed forward, overcoming the resilient force of spring **134**, to encase the retractor **112** and decrease angle **117** between the distal end of the retractor **112** and the central axis **101** of the cannula **100**. Upon releasing the button **107**, the spring force urges the proximal end **137** of the sliding tube **132** back toward the first position against button **107**. The sliding tube **132** is formed of material having sufficient strength to force the retractor **112** to straighten out the angle **117**, and the retractor **112** is formed of resilient material having a sufficient flexibility to straighten out the angle **117** in response to a tube **132** being slid over the retractor **112**, but having sufficient rigidity to cradle and dissect a target vessel. Resiliency of the retractor **112** ensures return to the downwardly-curved shape after being released from tube **132**. Thus, in accordance with this embodiment, a user may employ the curved retractor for certain applications and employ the straightened form for other applications. A manual actuator may be configured in other ways than button **107** to extend the sliding tube **132** in response, for example, to being pulled up instead of pushed down.

Another embodiment employs a retractor **112** which has a naturally straight shape. As illustrated in FIGS. 6*a* and 6*b*, an angling device **140** is disposed between the distal end of the retractor **112** and the proximal end of the cannula. The angling device **140** may be positioned within the same lumens **113** as the retractor **112** and preferably may comprise two wires coupled to points below the cradle **116** of the retractor **112** substantially in parallel positions on each of the legs **141**, **142**.

Upon extending the retractor **112** using button **106**, the angling device **140** is extended with the retractor **112**. The angling device **140** is coupled to a handle **145** at the proximal end of the cannula **100** to facilitate establishing an angle in the retractor **112** by pulling with a backward force on the angling device **140**. As illustrated in FIG. 6*b*, after the

retractor **112** is extended, the angling device **140** is actuated and a bend is created in the retractor **112** as the backward force exerted on the distal end of the retractor is exerted against the relatively fixed position of the retractor legs **141**, **142** disposed within the lumens **113**. As shown in FIG. **6***c*, the angling device **140** may also be located in a separate lumen **202** from the retractor **112** with part of the angling device **140** positioned outside of the cannula **100** when the retractor **112** is in the retracted position.

FIG. **7***a* illustrates another embodiment of cannula **100** in which the retractor **122** is pre-formed with one leg **141** of the retractor **112** bent at an angle at its proximal end skewed to the axis of the distal end of the other leg **142**. The bent portion of the leg **141** may be linked to a sliding knob **144** for convenient manual manipulation of this embodiment of the invention. Upon sliding the knob **144**, the leg **142** coupled to knob **144** is twisted rotationally. The two legs **141**, **142** of retractor **112** are coupled together via cradle **116**. The axis of the second portion of the retractor **112** in the first position is at a first angle **117** to the axis of the cannula **100**, as shown in FIG. **7***b*. As knob **144** is moved, leg **141** is rotated and crosses under leg **142**, as shown in FIG. **7***c*. This causes cradle **116** to flip 180 degrees and bends the retractor **112** at a second angle **119**, as shown in FIG. **7***d*. Thus, if a vessel is disposed on one side of cradle **116** or cannula **100** while the retractor **112** is in the first position, then upon rotating the knob **144**, the vessel is transported to the other side of the cannula **100**. This allows the user to isolate the vessel by simply actuating knob **144**.

FIG. **8***a* illustrates a cut-away side view of button **106** on the handle **104** of cannula **100**, with an endoscope **126** positioned within cannula **100**. As mentioned above, button **106** is coupled to one leg **141** of the proximal end of retractor **112**. Sliding the button **106** in groove **146** translationally moves the retractor **112**. Groove **146** is preferably minimally wider than the shaft of button **106** to minimize excessive horizontal movement of button **106** while still allowing smooth translational movement of button **106**. As illustrated in FIG. **8***b*, the button **106** may include locking or ratcheting teeth **152** to give tactile feedback of its location, and to positively retain the button and the associated leg **141** in an extended or retracted position. Several mating teeth **148** are located underneath groove **146**, and a spring member **150** is attached to button **106** to exert pressure against the base of groove **146**, to engage mating teeth **148**, **152**. When a force is applied on the top of button **106**, the interlocking sets of teeth are disengaged and button **106** can move freely. Upon achieving the desired extension or retraction of the leg **141**, button **106** is released and is retained place by the engaged teeth **148**, **152**.

FIG. **9***a* illustrates a top view of cradle **116** in an embodiment in which the cradle **116** is formed by two legs **141**, **142** of retractor **112**. The distal end of the legs form "U"-shaped side guides. The top **144** of the distal portion of the "U" is preferably flattened. This provides atraumatic support for the target vessel retained within cradle **116**. Additionally, by minimizing the thickness of distal portion **144**, contact with other devices in close proximity with retractor **112** is minimized.

The cradle **116** may have other effective shapes, for example, as illustrated in FIG. **9***b* in which a "C" ring element is attached to legs of the cradle **116**. The "C" ring may have a small hole **200** in one side with an axis approximately parallel to the axis of the retractor **112**. This hole **200** is used to hold suture or other ligating materials, and may also be used as a knot pusher. As shown in FIGS. **10***a* and **10***b*, in an alternate embodiment of the embodiment of FIG. **9***b*, the retractor **112** is formed and flattened and a "C"-shaped ring is coupled to the retractor **112** by, for example, gluing or molding the "C" ring to the distal end of the retractor **112**, as shown in FIG. **10***c* and **10***d*.

Referring back to FIGS. **9***c*, **9***d*, and **9***e*, the side guides of the cradle may include a loop **129** in a "V" shape, an arced "U" shape, or a semi-circular shape. In one embodiment, as illustrated in FIG. **9***f*, the retractor **112** has only one leg **141**, and the cradle **116** is formed by the leg **141**. A stopper **160** is coupled to the end of the leg **141** to serve as a guide to retain the target vessel, and add a blunt surface to the end of the wire, for example, for pushing and probing tissue. FIG. **9***g* illustrates a retractor **112** having a spur **204** formed in one or both legs **141**, **142** for allowing the retractor **112** to be used for dissection. Sinusoidal, half-sinusoidal, and other geometric configurations may be used equally effectively as the shape of loop **129** in accordance with the present invention.

FIG. **11** illustrates an alternate dissection cradle **312** for use in remote vessel ligation. Remote vessel ligation as discussed above is necessary to provide hemostasis to a vessel or other tissue after the vessel has been transected. In accordance with the present invention, hemostasis is accomplished by tightening suture formed in a loop adjacent the point of transection of the vessel. However, it is preferable to provide hemostasis to the vessel without incising the body a second time at the point of transection. The cannula **100** and dissection cradle **312** provide this functionality.

At the distal end of the retractor **312**, a shoulder part **300** is preferably formed of a rigid plastic encapsulating the distal end of the retractor **112**. A curved channel part **304** is attached to the shoulder **300**. The curved channel **304** is formed in the shape of a "C" as shown. The curve of curved channel **304** exposes a portion of the distal face of the shoulder **300**, upon which a suture loop **328** may be abutted, as shown in FIG. **12**. Other shapes, such as those shown in FIGS. **9***a–e*, may also be used as curved channel **304**.

FIG. **12** illustrates the manner in which the suture loop **328** is transported safely to the point of transection. The loop **328** is formed as a slipknot, which may be cinched tighter by exerting a backwards force on the free end of the suture **320**. The suture loop **328** is tied around the vessel and the curved channel part **312**, and is abutted against the shoulder **300**. Next, the loop **328** is tightened onto the curved channel **304** by pulling back on the free or proximal end of the suture **320**. The loop **328** is tightened sufficiently to permit safe advancement, but is provided with sufficient slack to allow displacement of the loop **328** onto the vessel adjacent the point of transection upon retraction of the retractor **312** into the cannula **100**.

One embodiment of the present invention for exerting a backward or disengaging force on the loop **328** is shown in FIG. **13**. FIG. **13** illustrates a tension mount **308** attached to cannula **100** for providing secure transport of the suture **320** to the surgical site of interest and for providing a controlling mechanism for tightening the suture loop **328** around the vessel when ligation is desired. The tension mount **308** is also formed of rigid plastic with some flexibility to allow other surgical tools **120** (not shown) to extend beyond the distal end of the tension mount **308**, and to allow atraumatic advancement of the tension mount **308** through the body. The distal end of the tension mount **308** includes a hole **324** through which the suture is threaded to tighten the suture loop **328**. The distal end of the tension mount **308** protrudes toward the central axis of the cannula **100**. This ensures that the vessel and the suture will be in the optimal position for

transection or cutting after the loop **328** has been displaced onto the vessel. Additionally, the forward angle of the tension mount **308** also ensures that the loop **328** will be displaced onto the vessel upon retraction of the retractor **312**, as discussed in greater detail below. The length of the tension mount **308** is chosen to allow the cradled vein to remain in endoscopic view upon advancement. Alternatively, a long knot pusher may be used in place of tension mount **308**. The suture **320** is looped around the vessel and the curved channel **304**, previously described. However, the free end of the suture **320** is threaded through a hole in the long knot pusher disposed within the cannula **100**. The cannula **100** and knot pusher are advanced to the point of transection. Displacement of the loop **328** occurs by advancing the knot pusher while maintaining the position of the dissection cradle **312** relative to the vessel. After the loop **328** is displaced onto the vessel, the loop **328** is tightened by pulling backward on the suture **320**. The long knot pusher may contain a lumen which runs the length of the cannula **100** or it may contain a shorter lumen which starts at the tip of the cannula and exits a side of the cannula **100** after a short distance proximally.

FIG. **14***a* illustrates the operation of the cannula **100** which has a tension mount **308**. The cradle **312** holds a vessel **330**. The vessel **330** is safely cradled in the curved channel **304** as the cannula **100** is advanced. The suture **320** is threaded through the hole **324** disposed in the distal end of the tension mount **308**. The distal end of the suture **320** is then formed into a suture loop **328** around the vessel **330**, and is abutted against the shoulder **300**. In this embodiment, the proximal end of the suture **320** is wrapped around a cleat **332** on button **106** at the proximal end of the cannula **100**. The loop **328** is tightened around curved channel **304** by winding the proximal end of the suture **320** around the cleat **332** which has the effect of pulling on the suture loop **328** and cinching the knot tightly around the curved channel **304** against the shoulder **300**. The suture loop **328** may now be safely advanced to the surgical site as excessive slack does not occur in the loop **328**, which would cause the loop **328** to be dislodged from the cradle **302**. In an alternate embodiment, the loop **328** is tightened responsive to the sliding of the button **106**. The button **106** has a lock with a release mechanism which restricts the sliding of the button **106**. When the loop **328** requires tightening after displacement onto the vessel, the lock is released and the button **106** is retracted. This embodiment ensures that the surgeon does not accidentally dislodge the loop **328** from the shoulder **300** by prematurely retracting the retractor **312** into the cannula **100**.

Upon reaching the site of interest, the loop **328** is displaced onto the vessel **330** by sliding a manual controller backwards, causing the retractor **112** to retreat to an axial position. In the embodiment of FIGS. **14***a* and *b*, the loop **328** is displaced by sliding the button **106** backwards. Upon sliding the button **106** backwards, as shown in FIG. **14***b*, the cradle **312** is retracted into cannula **100**, causing the loop **328** to be forcibly displaced from the shoulder **300** of the dissection cradle **312** onto the vein **330** at the desired location.

After displacement onto the vessel **330**, a knot tightener is then used to tighten the suture loop **328** onto the vessel **330** to provide hemostasis. In the embodiment of FIGS. **14***a* and *b*, the loop **328** is tightened onto the vessel **330** as the proximal end of the suture **320** is wound around the cleat **332**. The proximal end of the suture **320** could also simply be detached from the proximal end of the cannula **100**, and the loop **328** tightened by pulling on the free end of the suture **320**. Alternatively, the loop **328** may be tightened by fixing the proximal end to the button **106**. Sliding the button **106** towards the proximal end of the cannula **100** exerts a backwards force on the loop **328**, tighten the loop **328**.

FIG. **15** illustrates the use of the transection instrument **316** in accordance with the present invention. The transection instrument **316** is preferably endoscopic shears disposed within cannula **100**. The shears **316** are positioned between tension mount **308** and cradle **312**. After the vessel **330** has been ligated as described above, the shears **316** are extended to transect the vessel. As the vessel is tied by the suture **320** which passes into the tension mount **308**, the vessel is thus placed within easy reach of the blades of the shears **316**. The tension mount **308** is formed with a slight bend toward the center of the cannula **100** to facilitate keeping the vessel **330** within the apex of the open blades of the shears **316**. After transecting the vessel **330**, the vessel **330** will fall away as shown in FIG. **15**. The suture **320**, however, is now within the apex of the open blades of the shears **316**. The shears **316** are then extended again and used to cut the suture **320**. The ligated vessel **330** remains in the surgical site, and the graft is able to be removed through the first and only incision.

FIGS. **16***a–c* illustrates multiple views of tension mount **308**. FIG. **16***a* illustrates tension mount **308** attached to a collar **336**. The collar **336** allows the cannula **100** to be used without a tension mount **308** for the initial transection operation in which the tributaries of the vessel **330** are transected to allow the main length of the vessel to be extracted from the body. For this initial transection operation, the tension mount **308** may interfere with this procedure, and thus should be removed.

The collar **336** of the tension mount **308** has proximal and distal ridges **338**, **339** disposed on its inner surface. FIG. **16***b* illustrates in greater detail the proximal ridge **338** which mates with ridges disposed on the cannula surface. As shown in FIG. **16***c*, the distal end **342** of the cannula **100** is smooth plastic or other bioinert material on which the ridged collar **336** may slide easily. Ridges **346** situated at flat or recessed portions **345** on the surface of the body of cannula **100** form edges **344** for retaining the collar **336**. Upon sliding the collar **336** onto the distal end **342** of the cannula **100**, the collar **336** resiliently expands and ridges **338**, **339** of the collar **336** align with edges **344** of the cannula **100**. Upon alignment, the collar **336** resiliently contracts and thus forms a secure fitting of collar **336** on cannula **100**. When the surgeon wants to remove the collar **336**, the surgeon simply twists the collar **336** to misalign the ridges **338**, **339** of the collar with ridges **346** of the cannula **100**, causing the collar **336** to resiliently expand again, thus allowing the collar **336** to be easily removed from the cannula **100**.

FIG. **17** illustrates a method of performing remote vessel ligation in accordance with the present invention. The surgeon advances **1700** a suture loop **328** along a vessel to a remote site from incision. The suture loop **328** is displaced **1704** onto the vessel responsive to retraction of the retractor, and, responsive to exerting **1708** a backward force on the suture, the vessel is ligated.

In a further embodiment, as shown in FIG. **18**, the one-incision ligation and harvesting operation is performed under gas insufflation. First, an incision is made **1800** at the desired beginning point of the graft. For example, for saphenous vein harvesting for coronary artery bypass grafting, the incision is made at the knee. Next, the cannula **100** is inserted **1804** into the incision, and the incision is sealed **1808**. A tunnel is formed along the vessel by insufflating **1812** the area with gas. The suture loop **328** is safely

advanced **1816** to the destination. For saphenous vein harvesting, the loop **328** is advanced to its origin at the saphenofemeral junction. The loop **328** is displaced **1820** onto the vessel, and a backwards force is applied **1824** to the suture **320** to ligate the vessel. The vessel is transected **1828** and the suture is cut **1832**. The vessel can now be removed **1836** from the original incision. Thus, in accordance with the present invention, only one incision is required to harvest and ligate vessel in accordance with the present invention. The use of dissection cradle **312** allows the suture loop **328** of suture **320** to be advanced safely to the surgical site without being caught on the main trunk of the vessel or side branches thereof. The tension mount **308** accurately and reliably positions the vessel for transection and the suture **320** for cutting and provides the tension required to tighten the suture loop **328** of suture **320** onto a forward shoulder of the curved channel **304** for safe advancement and tensioning as required to provide hemostasic transection and harvesting of a target vessel.

What is claimed is:

1. Surgical apparatus comprising:

an elongated cannula including a plural number of lumens extending therein between proximal and distal ends thereof;

a retractor disposed within a lumen of the cannula to extend beyond the distal end of the cannula for engaging a vessel in response to movement of the retractor within the lumen to resiliently displace the vessel away from axial alignment with the elongated cannula; and

a surgical tool supported in a lumen of the elongated cannula and extending beyond the distal end thereof for simultaneous operation with the retractor for performing a surgical procedure on the vessel engaged by the retractor.

2. Surgical apparatus according to claim **1** in which the retractor and the surgical tool are relatively movable near the distal end of the cannula to facilitate severing a portion of the vessel engaged by the retractor.

3. Surgical apparatus comprising:

an elongated cannula including a plural number of lumens extending therein between proximal and distal ends thereof;

a retractor disposed within a lumen of the cannula to extend beyond the distal end of the cannula for engaging a vessel in response to movement of the retractor within the lumen, the retractor including at least one arm slidably disposed within said lumen of the cannula that supports a cradle in lateral orientation with respect to the arm; and

a surgical tool supported in a lumen of the elongated cannula and extending beyond the distal end thereof for performing a surgical procedure on a vessel engaged by the retractor.

4. Surgical apparatus according to claim **3** in which the cradle includes a generally U-shaped segment laterally oriented with respect to the arm.

5. Surgical apparatus according to claim **4** in which the arm includes a distal portion thereof that is laterally flexible and resiliently biased away from axial alignment with the elongated cannula.

6. Surgical apparatus according to claim **5** in which the U-shaped cradle includes a recess disposed to engage a vessel therein that is aligned in the direction of the resilient bias for resiliently deflecting a vessel engaged thereby away from axial alignment with the elongated cannula.

7. Surgical apparatus according to claim **3** including a pair of arms slidably disposed within lumens of the catheter and supporting the cradle therebetween at distal ends of the pair of arms.

8. A surgical procedure performed with an elongated cannula including a retractor and a surgical tool disposed near a distal end of the cannula, the procedure comprising the steps for:

positioning the distal end of the cannula near a target vessel;

engaging the target vessel with the retractor for resiliently displacing the target vessel laterally away from axial alignment with the elongated cannula; and

simultaneously engaging a branch vessel of the displaced target vessel with the surgical tool to sever the branch vessel from the target vessel.

9. The surgical procedure according to claim **8** in which the retractor and surgical tool are selectively deployed from the distal end of the cannula for simultaneous operation to sever the branch vessel from the target vessel.

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