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ASPIRATION CATHETER HAVING DISTAL SIDEWALL OPENING

Abstract

Systems and methods for removal of clot material from vessel lumens are disclosed. A thrombectomy system can include a tubular member having a proximal end region configured to be disposed extracorporeally and a distal end region configured to be disposed at an intravascular treatment site at or adjacent to a thrombus. The tubular member has a sidewall defining a lumen extending therethrough from the proximal end region to the distal end region. The sidewall has an opening in the distal end region, the opening including a proximal portion spanning a first width and a distal portion spanning a second width greater than the first width. The thrombectomy system can additionally include a suction source configured to be fluidically coupled to the lumen.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application claims the benefit of and priority to U.S. Provisional Patent Application Ser. No. 63/552,816 filed Feb. 13, 2024, the entire disclosure of which is incorporated by reference herein.

TECHNICAL FIELD
[0002] The present technology relates generally to systems and methods for removing obstructions from body lumens. Some embodiments of the present technology relate to aspiration catheters having distal sidewall openings.
BACKGROUND
[0003] Many medical procedures use medical device(s) to remove an obstruction (such as clot material) from a body lumen, vessel, or other organ. An inherent risk in such procedures is that mobilizing or otherwise disturbing the obstruction can potentially create further harm if the obstruction or a fragment thereof dislodges from the retrieval device. If all or a portion of the obstruction breaks free from the device and flows downstream, it is highly likely that the free material will become trapped in smaller and more tortuous anatomy. In many cases, the physician will no longer be able to use the same retrieval device to again remove the obstruction because the device may be too large and/or immobile to move the device to the site of the new obstruction.
[0004] Procedures for treating ischemic stroke by restoring flow within the cerebral vasculature are subject to the above concerns. The brain relies on its arteries and veins to supply oxygenated blood from the heart and lungs and to remove carbon dioxide and cellular waste from brain tissue. Blockages that interfere with this blood supply eventually cause the brain tissue to stop functioning. If the disruption in blood occurs for a sufficient amount of time, the continued lack of nutrients and oxygen causes irreversible cell death. Accordingly, it is desirable to provide immediate medical treatment of an ischemic stroke.
[0005] To access the cerebral vasculature, a physician typically advances a catheter from a remote part of the body (typically a leg) through the abdominal vasculature and into the cerebral region of the vasculature. Once within the cerebral vasculature, the physician deploys a device for retrieval of the obstruction causing the blockage, for example an aspiration catheter. Concerns about dislodged obstructions or the migration of dislodged fragments increases the duration of the procedure at a time when restoration of blood flow is paramount. Furthermore, a physician might be unaware of one or more fragments that dislodge from the initial obstruction and cause blockage of smaller more distal vessels. Accordingly, there remains a need for improved devices and methods that can remove occlusions from body lumens and/or vessels.
SUMMARY
[0006] The present technology is illustrated, for example, according to various aspects described below. Various examples of aspects of the present technology are described as numbered clauses (1, 2, 3, etc.) for convenience. These are provided as examples and do not limit the present technology. It is noted that any of the dependent clauses may be combined in any combination, and placed into a respective independent clause. The other clauses can be presented in a similar manner.
[0007] Clause 1. A thrombectomy system comprising: a thrombectomy device including a tubular member having a proximal end region configured to be disposed extracorporeally and a distal end region configured to be disposed at an intravascular treatment site at or adjacent to a thrombus, the tubular member comprising: a sidewall defining a lumen extending therethrough from the proximal end region to the distal end region; and an opening in the sidewall in the distal end region, the opening including a proximal portion spanning a first width and a distal portion spanning a second

width greater than the first width; and a suction source configured to be fluidically coupled to the lumen.
[0008] Clause 2. The thrombectomy system of Clause 1, further comprising a cover at least partially overlying the proximal portion of the opening.
[0009] Clause 3. The thrombectomy system of Clause 2, wherein the cover comprises a laminate material.
[0010] Clause 4. The thrombectomy system of Clause 2 or 3, wherein the suction source is configured to displace the cover from the proximal portion of the opening.
[0011] Clause 5. The thrombectomy system of Clause 4, wherein the cover is configured to be displaced proximally by the suction source.
[0012] Clause 6. The thrombectomy system of any one of the preceding Clauses, wherein when the suction source is coupled with the tubular member, the suction source applies a greater negative pressure in the distal portion of the opening than in the proximal portion of the opening.
[0013] Clause 7. The thrombectomy system of any one of the preceding Clauses, wherein the proximal portion of the opening spans a first length of the tubular member and the distal portion of the opening spans a second length of the tubular member less than the first length.
[0014] Clause 8. The thrombectomy system of any one of the preceding Clauses, further comprising a core member extending through the lumen.
[0015] Clause 9. The thrombectomy system of any one of the preceding Clauses, wherein the distal end region of the tubular member comprises a plurality of circumferential struts, the circumferential struts defining the opening.
[0016] Clause 10. The thrombectomy system of any one of the preceding Clauses, wherein the circumferential struts have a greater circumferential width in a proximal section than in a distal section.
[0017] Clause 11. The thrombectomy system of any one of the preceding Clauses, wherein the circumferential struts comprise an upper portion and a lower portion, the upper portion offset longitudinally from the lower portion.
[0018] Clause 12. The thrombectomy system of any one of the preceding Clauses, wherein the circumferential struts are connected to one another by one or more intermediate struts.
[0019] Clause 13. The thrombectomy system of any one of the preceding Clauses, further comprising a plurality of protrusions extending from the circumferential struts.
[0020] Clause 14. The thrombectomy system of any one of the preceding Clauses, wherein the protrusions are configured to prevent a core member from exiting the lumen through the opening.
[0021] Clause 15. The thrombectomy system of any one of the preceding Clauses, wherein the protrusions are configured to engage the thrombus.
[0022] Clause 16. The thrombectomy system of any one of the preceding Clauses, wherein the tubular member further comprises a distal opening on a distal face of the tubular member.
[0023] Clause 17. A method comprising: disposing a medical device within a vessel at or adjacent a treatment site, the medical device comprising: a tubular member, the tubular member having a side opening in a distal region of the tubular member, wherein the side opening comprises a proximal portion and a distal portion; and applying a negative pressure to the tubular member, wherein the negative pressure is greater in the distal portion of the side opening than in the proximal portion of the side opening for a first time period, and wherein the negative pressure in the distal portion of the side opening is less than or equal to the negative pressure in the proximal portion of the side opening for a second time period after the first time period.
[0024] Clause 18. The method of any one of the preceding Clauses, wherein the medical device further comprises a cover overlying the proximal portion of the side opening.
[0025] Clause 19. The method of any one of the preceding Clauses, wherein, during the first time period, the cover is in a first position, and during the second time period, the cover is in a second position proximal to the first position.

[0026] Clause 20. The method of any one of the preceding Clauses, wherein during the second time period, the cover is at least partially displaced.
[0027] Clause 21. The method of any one of the preceding Clauses, wherein the negative pressure is supplied by a suction source.
[0028] Clause 22. The method of any one of the preceding Clauses, wherein the proximal portion of the side opening occupies a first length of the tubular member and the distal portion of the side opening occupies a second length of the tubular member less than the first length.
[0029] Clause 23. The method of any one of the preceding Clauses, wherein the medical device further comprises a core member extending through a lumen of the tubular member.
[0030] Clause 24. The method of any one of the preceding Clauses, wherein the distal region of the tubular member comprises a plurality of circumferential struts, the circumferential struts defining the side opening.
[0031] Clause 25. The method of any one of the preceding Clauses, wherein the circumferential struts comprise an upper portion and a lower portion, the upper portion offset longitudinally from the lower portion.
[0032] Clause 26. The method of any one of the preceding Clauses, wherein the circumferential struts are connected to one another by one or more intermediate struts.
[0033] Clause 27. The method of any one of the preceding Clauses, wherein the medical device further comprises a plurality of protrusions extending from the circumferential struts.
[0034] Clause 28. The method of any one of the preceding Clauses, wherein the protrusions are configured to prevent the core member from exiting the lumen of the tubular member through the side opening.
[0035] Clause 29. The method of any one of the preceding Clauses, wherein the protrusions are configured to engage a thrombus at the treatment site.
[0036] Clause 30. A thrombectomy device comprising: a tubular member having a sidewall defining a lumen extending therethrough from a proximal end region to a distal end region, the tubular member configured to be fluidically coupled to a suction source to supply negative pressure to the lumen; an opening in the sidewall in the distal end region, the opening including a first portion and a second portion; and a rupturable cover extending over only the first portion of the opening such that the second portion of the opening is uncovered.
[0037] Clause 31. The thrombectomy device of any one of the preceding Clauses, wherein the first portion is proximal to the second portion.
[0038] Clause 32. The thrombectomy device of any one of the preceding Clauses, wherein the first portion has a smaller width than the second portion.
[0039] Clause 33. The thrombectomy device of any one of the preceding Clauses, wherein the first portion has a longer axial length than the second portion.
[0040] Additional features and advantages of the present technology are described below, and in part will be apparent from the description, or may be learned by practice of the present technology. The advantages of the present technology will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0041] Many aspects of the present technology can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale. Instead, emphasis is placed on illustrating clearly the principles of the present disclosure.
[0042] FIG. **1** shows a perspective view of a thrombectomy system for retrieving material from a body lumen, in accordance with one or more embodiments of the present technology.

[0043] FIG. **2**A illustrates an example distal end portion of the thrombectomy system of FIG. **1**.
[0044] FIG. **2**B illustrates another example distal end portion of the thrombectomy system of FIG. **1**.
[0045] FIG. **2**C illustrates an example distal end region of a thrombectomy device of the thrombectomy system shown in FIG. **2**B, in accordance with embodiments of the present technology.
[0046] FIG. **3** shows an example distal end region of a thrombectomy device, in accordance with embodiments of the present technology.
[0047] FIG. **4** shows another example distal end region of a thrombectomy device, in accordance with embodiments of the present technology.
[0048] FIG. **5** shows a further example distal end region of a thrombectomy device, in accordance with embodiments of the present technology.
[0049] FIGS. **6**A-**6**C illustrate an example method of deploying a thrombectomy device into a vessel, in accordance with embodiments of the present technology.
[0050] FIGS. **7**A-**7**C illustrate another example method of deploying a thrombectomy device into a vessel, in accordance with embodiments of the present technology.

DETAILED DESCRIPTION

[0051] The present technology relates to thrombectomy systems, devices, and methods for treating vascular obstructions, such as vessel occlusions, and associated devices and methods. In some embodiments, for example, a thrombectomy device includes a tubular member that can facilitate removal of a thrombus using aspiration to pull the thrombus into the tubular member lumen. In contrast to conventional aspiration catheters with a distal opening that is coaxial with the catheter lumen, in at least some embodiments of the present technology the tubular member can include an elongated opening in the sidewall instead of or in addition to a distal opening that is coaxial with the lumen. Additionally, the elongated sidewall opening can have a geometry such that the open space defined by the elongated sidewall opening is greater in the distal portion of the opening than in the proximal portion (e.g., the opening width can be greater in the distal portion than in the proximal portion). In operation, the tubular member can be disposed adjacent to a thrombus and suction can be applied to the tubular member lumen (e.g., via an extracorporeal pump or other suitable approach). The thrombus can then be adhered to the sidewall opening and/or pulled partially or completely into the lumen through the sidewall opening.
[0052] In some implementations, a temporary cover (e.g., a rupturable or separable polymer material) can be disposed over the sidewall opening along only the proximal portion, leaving the wider distal portion of the opening uncovered. In such configurations, when the tubular member is disposed adjacent to a thrombus and suction is applied, the thrombus may initially adhere to the uncovered distal portion of the sidewall opening, and at least a portion of the thrombus may begin to move through the distal portion of the sidewall opening into the lumen. In doing so, the fluid flow through the distal portion of the sidewall opening may decrease, thereby exerting increased pressure on the temporary cover over the proximal portion of the sidewall opening. The temporary cover can be configured to rupture, peel, separate, or otherwise become displaced, thereby uncovering the proximal portion of the opening. In some instances, this displacement can occur gradually in the distal-to-proximal direction, creating a zipper-like effect in which the proximal portion of the sidewall opening is gradually uncovered. As this proximal portion is uncovered, the thrombus can adhere to and/or be drawn into the lumen through the proximal portion of the sidewall opening.
[0053] The systems of the present technology can provide many advantages compared to conventional devices for treating vascular obstructions. The opening in the sidewall of the tubular member enables the system to engage multiple portions of the clotting material simultaneously or substantially simultaneously. In contrast, conventional systems typically include an aspiration catheter with only an opening on a distal face of the aspiration catheter. As a result, conventional

systems have limited engagement with clotting material (e.g., engagement of only a proximal end portion of the clotting material). Conventional aspiration catheters are also susceptible to "corking," in which the thrombus completely blocks the distal opening of the aspiration catheter, but the clot is unable to be pulled into the catheter lumen for removal. Moreover, such "corking" only grasps a small area of the thrombus (e.g., only a proximal-most portion), and accordingly attempts to retract the aspiration catheter with the corked thrombus intact often leads to clot fragmentation, risking downstream embolization. This problem is particularly acute in the small vessels of the neurovasculature, as the small catheters required for accessing these vessels necessarily have small lumens. Improved thrombus engagement, as provided with the present technology, reduces the risk of clot fragmentation, snaring of the thrombectomy system, further occlusion of vessels, arrest of flow rate, and more. Additionally, the tubular member, as further described herein, can have a slim profile with a low delivery force, reducing the risk of vessel perforation and/or damage. In some embodiments, the opening in the sidewall is configured such that suction is preferentially applied in a distal region of the clotting material. Further advantages will be made apparent with reference to embodiments of the present technology.

[0054] Embodiments of the present disclosure will be described more fully hereinafter with reference to the accompanying drawings in which like numerals represent like elements throughout the several figures, and in which example embodiments are shown. Embodiments of the claims may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. The examples set forth herein are non-limiting examples and are merely examples among other possible examples.

[0055] As used herein, the terms "vertical," "lateral," "upper," and "lower" can refer to relative directions or positions of features of the embodiments disclosed herein in view of the orientation shown in the Figures. For example, "upper" or "uppermost" can refer to a feature positioned closer to the top of a page than another feature. These terms, however, should be construed broadly to include embodiments having other orientations, such as inverted or inclined orientations where top/bottom, over/under, above/below, up/down, and left/right can be interchanged depending on the orientation.

I. OVERVIEW OF EXAMPLE TREATMENT SYSTEMS AND DEVICES

[0056] The present technology provides systems, devices, and methods for removing clot material from a blood vessel lumen. Although many of the embodiments are described below with respect to devices, systems, and methods for treating a cerebral or intracranial embolism, other applications and other embodiments in addition to those described herein are within the scope of the technology. For example, the treatment systems and methods of the present technology may be used to remove emboli from body lumens other than blood vessels (e.g., the digestive tract, etc.) and/or may be used to remove emboli from blood vessels outside of the brain (e.g., pulmonary, abdominal, cervical, or thoracic blood vessels, or peripheral blood vessels including those within the legs or arms, etc.). In addition, the treatment systems and methods of the present technology may be used to remove luminal obstructions other than clot material (e.g., plaque, resected tissue, foreign material, etc.).

[0057] FIG. **1** illustrates a view of a thrombectomy system **100** according to one or more embodiments of the present technology. As shown in FIG. **1**, the thrombectomy system **100** can include a medical device assembly **101** and a suction source **103**. The medical device assembly **101** includes a proximal portion **101***a* configured to be coupled to the suction source **103** and a distal portion **101***b* configured to be intravascularly positioned within a blood vessel (such as an intracranial blood vessel) at a treatment site at or proximate a thrombus. The medical device assembly **101** includes a handle **102** at the proximal portion **101***a*. A plurality of elongated shafts or tubular members extend between the proximal portion **101***a* and the distal portion **101***b*. For example, in some embodiments, such as that shown in FIG. **1**, the medical device assembly **101** includes a first or guide catheter **105** (e.g., a balloon-guide catheter), a distal access catheter **107**

configured to be slidably disposed within a lumen of the guide catheter **105**, a thrombectomy device **109** in the form of a tubular member (e.g., an aspiration catheter) configured to be slidably disposed within a lumen of the distal access catheter **107**, and a guidewire or guidewire **111** configured to be slidably disposed within a lumen of the thrombectomy device **109**. In some embodiments, the medical device assembly **101** does not include one or more of the guide catheter **105**, distal access **107**, thrombectomy device **109**, or the guidewire **111**.

[0058] In operation, one or more of the guide catheter **105**, the distal access catheter **107**, and thrombectomy device **109** can be used as an aspiration catheter to remove a clot or other material such as plaques or foreign bodies from vasculature of a patient. For example, a vacuum may be applied to proximal end of the thrombectomy device **109** (e.g., via suction source **103**) to draw a clot or other blockage into an inner lumen of the thrombectomy device **109**. In some embodiments, the vacuum causes the clot or other blockage to remain attached to the thrombectomy device **109** (e.g., on an outer surface of the thrombectomy device **109**). Such aspiration may be used in various medical procedures, such as a medical procedure to treat an ischemic insult, which may occur due to occlusion of a blood vessel (arterial or venous) that deprives brain tissue, heart tissue or other tissues of oxygen-carrying blood.

[0059] With continued reference to FIG. **1**, in some examples, the thrombectomy device **109** can be configured to access relatively distal locations in a patient including, for example, the middle cerebral artery (MCA), internal carotid artery (ICA), the Circle of Willis, and tissue sites more distal than the MCA, ICA, and the Circle of Willis. The MCA, as well as other vasculature in the brain or other relatively distal tissue sites (e.g., relative to the vascular access point), may be relatively difficult to reach with a tubular member, due at least in part to the tortuous pathway (e.g., comprising relatively sharp twists or turns) through the vasculature to reach these tissue sites. As such, the tubular member may be structurally configured to be relatively flexible, pushable, and relatively kink- and buckle-resistant, so that it may resist buckling when a pushing force is applied to a relatively proximal section of the tubular member to advance the tubular member distally through vasculature, and so that it may resist kinking when traversing around a tight turn in the vasculature. In some examples, the tubular member is configured to substantially conform to the curvature of the vasculature. In addition, in some examples, the tubular member has a column strength and flexibility that allow at least a distal portion of the tubular member to be navigated from a femoral artery, through the aorta of the patient, and into the intracranial vascular system of the patient, e.g., to reach a relatively distal treatment site.

[0060] Although primarily described as being used to reach relatively distal vasculature sites, the thrombectomy device **109** may also be configured to be used with other target tissue sites. For example, thrombectomy device **109** may be used to access tissue sites throughout the coronary and peripheral vasculature, the gastrointestinal tract, the urethra, ureters, fallopian tubes, veins and other body lumens.

[0061] According to some embodiments, the guide catheter **105** and the distal access catheter **107** can each be formed as additional tubular members extending along and about a central axis and terminating in respective distal ends. According to some embodiments, the distal access catheter **107** is generally constructed to track over the guidewire **111** in the cervical anatomy and into the cerebral vessels associated with the brain and may also be chosen according to several standard designs that are generally available. Accordingly, the distal access catheter **107** can have a length that is at least 125 cm long, and more particularly may be between about 125 cm and about 175 cm long.

[0062] The thrombectomy device **109** can be sized and configured to be slidably advanced over the guidewire **111**. As noted above, the thrombectomy device **109** can be coupled at a proximal portion to a suction source **103** such as a pump or syringe in order to supply negative pressure to a treatment site. In various embodiments, the thrombectomy device **109** can have a length that is at least 125 cm long, and more particularly may be between about 125 cm and about 175 cm long. In

some embodiments, the thrombectomy device **109** can be an aspiration catheter. The thrombectomy device **109** can have a lumen diameter of a between about 0.05″ and about 0.09″, for example about 0.061″, about 0.068″, or about 0.071″ lumen diameter. The tubular member **107** can have a maximum outer diameter of between about 0.06″ to about 0.1″, for example about 0.083″, or about 0.0855″. Other designs and dimensions are contemplated.

[0063] The guide catheter **105** can be sized and configured to slidably receive both the distal access catheter **107** and the thrombectomy device **109** therethrough. In some embodiments, the guide catheter **105** is a balloon-guide catheter having an inflatable balloon or other expandable member that can be used to anchor the guide catheter **105** with respect to a surrounding vessel. In operation the guide catheter **105** can first be advanced through a vessel and then a balloon can be expanded to anchor the guide catheter **105** in place and/or arrest blood flow from areas proximal of the balloon. Next, the distal access catheter **107** and the thrombectomy device **109** can be advanced together through the guide catheter **105** until they each extend distally beyond the distal end of the guide catheter **105**. Suction can then be applied to aspirate the treatment site.

[0064] According to some embodiments, the bodies of the catheter **105**, distal access catheter **107**, and/or thrombectomy device **109** can be made from various thermoplastics, e.g., polytetrafluoroethylene (PTFE or TEFLON®), fluorinated ethylene propylene (FEP), high-density polyethylene (HDPE), polyether ether ketone (PEEK), etc., which can optionally be lined on the inner surface of the catheters and/or tubular member or an adjacent surface with a hydrophilic material such as polyvinylpyrrolidone (PVP) or some other plastic coating. Additionally, either surface can be coated with various combinations of different materials, depending upon the desired results. As described in more detail below, some or all of the thrombectomy device **109** can be formed of a metallic material, such as Nitinol, stainless steel, or other suitable material. In some examples, the thrombectomy device **109** can include a laser-cut hypotube having a pattern of cut voids (e.g. spiral cut, separated slot cuts, or other suitable pattern) formed in its sidewall along at least a portion of its length. In at least some embodiments, the thrombectomy device **109** can have a laser cut pattern to achieve the desired mechanical characteristics (e.g., column strength, flexibility, kink-resistance, etc.).

[0065] In various embodiments, the guidewire **111** can be a solid pushwire or guidewire. Additionally or alternatively, the guidewire **111** can instead include a hollow wire, hypotube, braid, coil, or other suitable member(s), or a combination of wire(s), tube(s), braid(s), coil(s), etc. In some embodiments, the guidewire **111** can be made of stainless steel (e.g., 304 SS), Nitinol, and/or other alloy.

II. SELECT EXAMPLES OF THROMBECTOMY DEVICES HAVING DISTAL SIDE OPENINGS

[0066] FIGS. **2**A-**2**C illustrate example enlarged detail views of the distal portion **101***b* of the thrombectomy system **100** of FIG. **1**. Referring first to FIG. **2**A, the thrombectomy system **100** is configured to be deployed at an intravascular treatment site (e.g., at or adjacent to a thrombus). A guidewire **111** slidably extends through a lumen of the thrombectomy device **109**, which in turn slidably extends through a lumen of the surrounding catheter **107**. As noted elsewhere herein, the thrombectomy system **100** can include a suction source **103**, such that when suction is applied, the thrombectomy device **109** is configured to engage clotting material.

[0067] In some embodiments, the thrombectomy device **109** is a tubular member having an opening **201** in a sidewall of the tube. The opening **201** can be configured to fluidically couple the lumen of the thrombectomy device **109** with the surrounding environment. The opening **201** can have any variety of geometries. For example, the opening **201** can be substantially oblong. Alternatively, or in addition, the opening **201** can include straight, arcuate, curved, semi-circular, or semi-elliptical shapes. The opening **201** can also include complex shapes, such as zig-zag, undulating, serpentine, sinusoidal, or a combination thereof.

[0068] As shown in FIG. **2**A, the opening **201** can include a proximal portion **201***a* and a distal

portion **201***b*. In some embodiments, the proximal portion **201***a* spans a greater length of the thrombectomy device **109** than the distal portion **201***b*. Further, the proximal portion **201***a* can span a smaller radial or circumferential width of the thrombectomy device **109** than the distal portion **201***b*. In some embodiments, a smaller length and a greater radial or circumferential width in the proximal portion **201***a* advantageously allows the thrombectomy device **109** to facilitate a greater flow rate in the distal portion **201***b* than in the proximal portion **201***a* when the thrombectomy device **109** is coupled to a suction source. While the opening **201** is depicted as having portions of two different shapes, the opening **201** can include any number of different shapes, e.g., at least one, two, three, four, five, six, seven, eight, nine, or ten shapes. Alternatively, or in combination, the opening **201** can be tapered from the proximal portion **201***a* to the distal portion **201***b*.

[0069] In some embodiments, the opening **201** is a continuous opening. For example, in some embodiments, the proximal portion **201***a* and the distal portion **201***b* are connected (e.g., span an unoccupied surface area of the thrombectomy device **109**). Alternatively, or in combination, the first opening **201** can be a first opening **201** of a plurality of openings in the sidewall of the thrombectomy device **109**. For example, the first opening **201** can occupy a first surface area and a second opening (not depicted) of the plurality of openings can occupy a second surface area different from the first surface area. In such cases, the first opening **201** and the second opening are separated by at least a portion of the thrombectomy device **109**.

[0070] The thrombectomy device **109** can further include a distal opening **203** (e.g., a distal-facing mouth at the distal end of the thrombectomy device **109**). In some embodiments, the distal opening **203** is configured to permit passage of the guidewire **111** therethrough, allowing the thrombectomy device **109** to be slidably advanced over the guidewire **111**. Additionally, or alternatively, the distal opening **203** can be configured to aspirate clotting material. For example, when the thrombectomy device **109** is coupled to the suction source **103**, the thrombectomy device **109** can engage clotting material via the distal opening **203**. In some embodiments, engaging the clotting material via the distal opening **203** includes aspirating remnants of clotting material not engaged via the opening **201**. A distal end of the sidewall opening **201** and the distal opening **203** can be separated from one another along the longitudinal axis of the thrombectomy device **109** by at least 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 10 mm, 20 mm, 50 mm, 100 mm, 1 cm, etc.

[0071] As depicted in FIGS. **2**B and **2**C, in some embodiments the opening in the sidewall of the thrombectomy device **109** is at least partially covered. Referring now to FIG. **2**B, opening **201** is at least partially covered by a cover **205**. Among examples, the proximal portion **201***a* of the sidewall opening **201** may be covered via the cover **205**, while the distal portion **201***b* of the sidewall opening may be uncovered. The cover **205** can be configured to temporarily prevent passage of material from the environment into the thrombectomy device **109**. In some embodiments, the cover **205** covers proximal portion **201***a* of the opening **201**. For example, the cover **205** can cover at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100% of the proximal portion **201***a*. Alternatively, or in combination, the cover **205** can cover at least some of distal portion **201***b* of the opening **201**. For example, the cover **205** can cover at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100% of the distal portion **201***b*.

[0072] The cover **205** can be attached to an external surface of the thrombectomy device **109**. For example, the cover **205** can be connected to the thrombectomy device **109** by one or more of bonding, adhesives, welding, etc. Alternatively, or in combination, the cover **205** can be attached to an internal surface of the thrombectomy device **109**.

[0073] The cover **205** can generally be configured to detach and/or release itself from the tubular member sidewall. In some embodiments, the cover **205** ruptures (e.g., breaks apart), tears, dissolves, or disintegrates, or otherwise ceases to cover the sidewall opening **201**. The cover **205** can rupture in response to an engagement of the thrombectomy device **109** with clotting material. In some embodiments, the cover **205** ruptures in response to negative pressure applied by a suction source (e.g., the suction source **103**), such that the cover **205** is at least partially displaced inwardly

into the thrombectomy device **109**. In some embodiments, the cover **205** ruptures along a midline of the cover **205**. For example, the cover **205** may separate symmetrically about the longitudinal axis.

[0074] In some embodiments, the cover has a varying thickness. For example, the cover **205** can have a greater thickness in a proximal portion of the cover **205** than in a distal portion of the cover **205**. In some embodiments, the cover **205** has a gradient thickness, e.g., a decreasing thickness from the proximal portion of the cover **205** to the distal portion of the cover **205**. Varying the thickness of the cover **205** may advantageously cause the cover to rupture in a predetermined fashion. For example, when the cover **205** has a decreasing thickness from the proximal portion of the cover **205** to the distal portion of the cover **205**, the cover **205** may rupture in the distal portion before the proximal portion. However, the cover **205** may be modified and/or configured in other ways that affect the manner in which the cover **205** ruptures. For example, the cover **205** may still preferentially rupture from the distal portion to the proximal portion while having a uniform thickness.

[0075] The cover can include any variety of materials. In some embodiments, the cover **205** includes one or more substantially impermeable material(s). For example, the cover **205** can include a laminate material. In some embodiments, the cover **205** includes PFTE, Pebax, polymers, etc. In some embodiments, the cover **205** includes a heat shrink material. Manufacture of the cover **205** may involve any number of lamination processes. The cover **205** can further be configured to be hydrophilic, e.g., having a phosphorocholine compound. Additionally, or alternatively, some or all of the cover **205** can include materials that enhance blood compatibility and/or reduces thrombogenic surface activity.

[0076] While the cover **205** is depicted as a continuous cover, in some embodiments, the cover **205** can include multiple segments. For example, the cover **205** can have a proximal segment, an intermediate segment, and a distal segment. In some embodiments, the proximal segment, the intermediate segment, and the distal segment are separated. For example, the proximal segment and the intermediate segment can be separated by at least 1 mm, 2 mm, 3 mm, 5 mm, 10 mm, 20 mm, 50 mm, 100 mm, 500 mm, etc. In some embodiments, any one of the proximal segment, the intermediate segment, and the distal segment can omitted. When the cover **205** comprises multiple segments, the cover **205** can selectively detach from the thrombectomy device **109**. For example, in some embodiments, the distal segment of the cover **205** detaches from the thrombectomy device **109** before the proximal segment of the cover **205** detaches from the thrombectomy device **109**.

[0077] FIG. **2**C shows an enlarged detail view of the distal end region of the thrombectomy device **109**, in which relative dimensions of the sidewall opening **201** and the cover **205** are shown. As illustrated, the sidewall opening **201** can span a first length D**1**. In some embodiments, the first length D**1** is no more than 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, 15 mm, 20 mm, 30 mm, 40 mm, or 50 mm. In some embodiments, the first length D**1** is at least about 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, 15 mm, 20 mm, 30 mm, 40 mm, or 50 mm. D**1** can be the combined length of length D**2**, corresponding to the proximal portion **201***a*, and length D**3**, corresponding to the distal portion **201***b*.

[0078] Cover **205** can span a substantial portion of proximal portion **201***a* and/or distal portion **201***b* of the opening **201**. For example, the cover **205** can span a length that is at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100% of D**2** and/or no more than 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% of D**3**.

[0079] In some embodiments, the distal portion **201***b* of the opening **201** is separated by the distal cover **205** by a length D**4**. Length D**4** can be smaller than lengths D**1**, D**2**, and/or D**3**. In some embodiments, length D**4** is at least about 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 10 mm, 20 mm, 50 mm, 100 mm, 1 cm, etc. In some embodiments, length D**4** is no more than about 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 10 mm, 20 mm, 50 mm, 100 mm, 1 cm, etc.

[0080] In some embodiments, proximal portion **201***a* of the opening **201** has a smaller diameter D**5**

than the diameter D**6** of the distal portion **201***b* of the opening **201**. For example, D**5** can be no more than 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% of D**6**. In some embodiments, D**5** and D**6** are the same, e.g., having equal diameters. Alternatively, D**5** can be greater than D**6**, e.g., when the proximal portion **201***a* spans a greater radial width than the distal portion **201***b*.

[0081] Diameters D**5** and D**6** can be smaller than D**7**, the diameter of thrombectomy device **109**. In some embodiments, the greater one of D**5** and D**6** is no more than 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% of D**7**.

[0082] In some examples, the body of the tubular member of the thrombectomy device **109** can have cuts, recesses, grooves, struts, or other features that provide enhanced flexibility for improved navigation in the tortuous anatomy of the neurovasculature. FIG. **3** shows an example distal end region of a thrombectomy device including such struts, in accordance with embodiments of the present technology. As depicted, the distal end region of thrombectomy device **309** can include a plurality of circumferential struts **313**. In some embodiments, the circumferential struts **313** have the same diameter as thrombectomy device **109**. The circumferential struts **313** can span a different (e.g., smaller) arc length than the rest of the thrombectomy device **309**. For example, the circumferential struts **313** can span an arc length that is no more than 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% of the arc length (e.g., total circumference) of the thrombectomy device **109**. In some embodiments, each of the circumferential struts **313** span the same arc length with a common central angle. However, in some embodiments, the arc length and/or central angle may vary across circumferential struts **313**.

[0083] The circumferential struts **313** can be equally spaced apart along the longitudinal axis. For example, in some embodiments, the distance between neighboring circumferential struts **313** is no more than 2.5 mm, 2.25 mm, 2 mm, 1.75 mm, 1.5 mm, 1.25 mm, 1 mm, 0.75 mm, or 0.5 mm. Alternatively, the circumferential struts **313** can include a variety of spacings therebetween. For example, in some embodiments, intermediate spacings between the circumferential struts **313** increases distally such that the circumferential struts **313** are closer together in a proximal portion than in a distal portion. The circumferential struts **313** can include any number of circumferential struts. For example, the circumferential struts **313** can comprise at least one, two, three, four, five, six, seven, eight, nine, ten, 20, or more circumferential struts.

[0084] The circumferential struts can form a sidewall opening **301**. For example, portions of the circumferential struts **313** that depart from the rest of the thrombectomy device **109** can form an opening **301** including a plurality of recesses and/or channels. The opening **301** can fluidically couple the lumen of the thrombectomy device **109** with the surrounding environment. In some embodiments, the opening **301** is configured to receive clotting material from the surrounding environment. The opening **301** can be generally similar to the opening **201** of FIGS. **2**A-**2**C and provide similar advantages and/or functionalities.

[0085] In some embodiments, the circumferential struts are integral to the tubular member. For example, the circumferential struts **313** can be formed via the removal of material from the thrombectomy device **309**. Alternatively, the circumferential struts **313** and the rest of the thrombectomy device **309** can be discrete components that are attached to each other, e.g., via welding, adhesives, fasteners, or other suitable techniques.

[0086] The circumferential struts **313** can have different material properties from the rest of the thrombectomy device **309**. For example, the circumferential struts **313** can include one or more additional materials that affect a stiffness and/or elastic modulus of the circumferential struts **313**. For instance, the circumferential struts **313** can include a lower stiffness than the rest of the thrombectomy device **309**. In such cases, the circumferential struts **313** may more easily fold and/or collapse than the rest of the thrombectomy device **309**, e.g., when one or more forces are imparted on the thrombectomy device **309**.

[0087] In some embodiments, intermediate spacings between the circumferential struts **313** form a plurality of secondary openings **302**. The circumferential struts **313** can be configured to compress

and expand such that the secondary openings **302** increase or decrease in volume in response to movement of the thrombectomy device **109**.

[0088] In some embodiments, the circumferential struts comprise an upper portion and a lower portion. Turning now to FIG. **4**, an example distal end region of a thrombectomy device, in accordance with embodiments of the present technology, is shown. The distal end portion of tubular member **409** can include a plurality of circumferential struts **413** that are generally similar to the circumferential struts **313** of FIG. **3**. In some embodiments, upper portion **413***a* and lower portion **413***b* are offset from one another. For example, the upper portion **413***a* can include circumferential struts that are distal to corresponding circumferential struts of the lower portion **413***b* by at least 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 10 mm, 20 mm, 50 mm, 100 mm, 1 cm, etc. In some embodiments, offsetting the lower portion **413***b* from the upper portion **413***a*, or vice-versa, advantageously provides greater flexibility and maneuverability of the thrombectomy device **109**.

[0089] In some embodiments, at least some of the circumferential struts **413** are attached to one another by one or more intermediate struts **415**. The intermediate struts **415** can have straight, arcuate, curved, semi-circular, or semi-elliptical shapes. The intermediate struts **415** may connect a more proximally located circumferential strut to a more distally located circumferential strut. In some embodiments, connecting two or more circumferential struts **413** with intermediate struts **415** advantageously provides greater support and may allow for easier deployment of the thrombectomy device **109** in a vessel of a patient.

[0090] The intermediate struts **415** can be a separate component from the circumferential struts **413** or can be an integral component of the circumferential struts **413**. In some embodiments, the intermediate struts **415** have a smaller thickness than the circumferential struts **413**. Optionally, the intermediate struts **415** may include one or more different materials from the circumferential struts **413** that affect the stiffness and/or elastic modulus of the intermediate struts **415**. For example, the intermediate struts **415** may include materials that result in the intermediate struts **415** having a lower stiffness than the circumferential struts **413**.

[0091] In some embodiments, one or more protrusions extend from the circumferential struts. Turning now to FIG. **5**, one or more protrusions **517** extend from circumferential struts **513**. The one or more protrusions **517** can include one or more of tines, barbs, fixation members, hooks, rods, elongate members, or any other suitable engagement bodies. The one or more protrusions **517** can extend from the circumferential struts **513** at an angle from about 0 to 10 degrees, 10 to 20 degrees, 30 to 40 degrees, 40 to 50 degrees, 50 to 60 degrees, 70 to 80 degrees, or 80 to 90 degrees.

[0092] The one or more protrusions **517** may serve multiple purposes. For example, the one or more protrusions **517** can be configured to prevent guidewire **511** from leaving a lumen of the thrombectomy device **509**. For instance, the protrusions **517** can form retention members configured to retain the guidewire **511** within the lumen of the thrombectomy device **509**. In some embodiments, the one or more protrusions **517** are configured to engage the clotting material by one or more of displacing, penetrating, catching, grappling, or entrapping the clotting material. As will be discussed further below, the protrusions **517** can be configured to engage the clotting material while the thrombectomy device **509** is removed from a bodily lumen.

[0093] In some embodiments, the one or more protrusions **517** are coupled to more than one circumferential strut. For example, a protrusion **517** can extend from a circumferential strut to a neighboring circumferential strut. In such cases, the protrusion **517** can act as a guarding structure to prevent the guidewire **111** from leaving the lumen of the thrombectomy device **509**.

III. EXAMPLE THROMBECTOMY METHODS

[0094] The thrombectomy devices and systems provided herein can be used in treating a variety of vessel occlusions. Although the methods are described herein primarily with reference to a thrombectomy device with Figure-specific reference numbers for clarity, it should be understood that the methods described herein may additionally or alternatively be performed with any suitable variation of thrombectomy devices in accordance with the present technology (e.g., thrombectomy

system **100**), such as those described above with respect to FIGS. **1**A-**5**. Some methods will now be illustrated with respect to FIGS. **6**A-**7**C.

[0095] FIGS. **6**A-**6**C illustrate an example method of deploying a thrombectomy system into a vessel, in accordance with embodiments of the present technology. The thrombectomy system **100** can include thrombectomy device **109** having a sidewall opening **201** and cover **205**.

[0096] Referring now to FIG. **6**A, a guidewire **111** is distally advanced in a blood vessel V, followed by the distal advancement of a catheter **107** and/or thrombectomy device **109**. In some embodiments, the thrombectomy device **109** is distally advanced within the guide catheter **105**. Alternatively, or in combination, the catheter **107** may be retracted at a treatment site, leaving the thrombectomy device **109** in place and at least partially outside a lumen of the guide catheter **105**. The cover **205** may be coupled to the thrombectomy device **109** for the entirety of the distal advancement of the thrombectomy device **109** to the treatment site. After the thrombectomy device **109** is placed at the treatment site, guidewire **111** may be removed, e.g., proximally withdrawn. Optionally, the catheter **107** can similarly be withdrawn from the blood vessel V.

[0097] In some embodiments, the thrombectomy system **100** includes a suction source (not depicted). The suction source can be coupled to the thrombectomy device **109** and is configured to apply negative pressure within a lumen of the thrombectomy device **109**. When the suction source is coupled to the thrombectomy device **109**, clot material can be pulled against the uncovered portion of the sidewall opening **201**. In some instances, this engagement can result in a “corking” effect, in which fluid flow through the sidewall opening **201** is temporarily occluded. As suction continues to be applied, the suction source can initiate a rupturing of the cover **205**. For example, when the suction source applies suction to the thrombectomy device **109**, the cover **205** can begin to rupture from the distal end to the proximal end, as previously discussed herein.

[0098] FIG. **6**B shows the cover **205** in a partially ruptured state. In some embodiments, wherein the cover **205** is a mesh, rupturing the cover **205** includes tearing and/or ripping off the mesh. In some embodiments, wherein the cover **205** is a single continuous layer, the cover **205** is separated along a midline of the cover **205**. In response to one or more forces imparted by the suction source or other external energy source, the cover **205** can be displaced inwardly to a lumen of the thrombectomy device **109**. As the cover **205** is ruptured, fluid flows (due to the applied suction) through the uncovered portions of the sidewall opening **201**, causing the clot material to be adhered to those uncovered portions of the opening. As such, the engagement area between the clot and the sidewall opening **201** increases as the cover **205** is ruptured.

[0099] In some embodiments, the cover **205** is aspirated proximally such that the cover **205** is displaced by the suction source and leaves the opening **201** unobstructed. For example, when the cover **205** ruptures and is no longer attached to the thrombectomy device **109**, the opening **201** can fluidically couple the lumen of the thrombectomy device **109** with the surrounding environment, as depicted in FIG. **6**C.

[0100] FIGS. **7**A-**7**C illustrate another example method of deploying a thrombectomy device into a vessel, in accordance with embodiments of the present technology. The thrombectomy system **100** can include thrombectomy device **109** having an opening **201** and a cover **205**.

[0101] Referring now to FIG. **7**A, guidewire **111** is advanced distally in a blood vessel V, followed by the distal advancement of guide catheter **105** and/or thrombectomy device **109**. In some embodiments, the thrombectomy device **109** is distally advanced within guide catheter **105**. Alternatively, or in combination, the guide catheter **105** may be retracted at a treatment site, leaving the thrombectomy device **109** in place and at least partially outside a lumen of the guide catheter **105**. The cover **205** may be coupled to the thrombectomy device **109** for the entirety of the distal advancement of the thrombectomy device **109** to the treatment site. After the thrombectomy device **109** is placed at the treatment site, guidewire **111** may be removed, e.g., proximally withdrawn. Optionally, the guide catheter **105** can similarly be withdrawn from the blood vessel V.

[0102] In some embodiments, the thrombectomy device **109** is rotated such that the opening **201**

faces the thrombus T. For example, a handle (not shown) may be coupled to the thrombectomy device **109** at a proximal end region of the thrombectomy device **109**. An operator, e.g., a physician, can rotate the handle to assume a favorable position for aspirating clotting material from the blood vessel V. The thrombectomy device **109** can be coupled to a suction source (not shown). The suction source can be configured to cause negative pressure in the lumen of the thrombectomy device **109**.

[0103] After the thrombectomy device **109** is appropriately placed at or adjacent to the thrombus T, as depicted in FIG. **7**B, the cover can begin to rupture. For example, in some embodiments, when the suction source is coupled to the thrombectomy device **109**, the cover **205** begins to rupture from the distal end to the proximal end. Negative pressure applied by the suction source can cause the distal end of the cover **205** to break apart, increasing the size of the opening **201**. In some embodiments, the cover **205** is displaced proximally. In some embodiments, the cover **205** is displaced into the lumen of the thrombectomy device **109**.

[0104] After the cover **205** is removed from the thrombectomy device **109**, the suction source can continue to provide negative pressure to the lumen of the thrombectomy device **109**. In some embodiments, the suction source is configured to cause the thrombectomy device **109** to engage the thrombus T at the opening **201**. For example, negative pressure provided by the suction source can cause the thrombus T to be at least partially drawn inward to the lumen of the thrombectomy device **109**. In some embodiments, the opening **201** is configured to engage the thrombus T without the thrombus T entering the lumen of the thrombectomy device **109**. For example, the opening **201** can include a plurality of protrusions (e.g., such as the protrusions **517** of FIG. **5**).

[0105] After the thrombus T engages the thrombectomy device **109** at the opening **201**, the thrombectomy device **109** can be retracted. In some embodiments, the thrombectomy device **109** is completely removed from the blood vessel V. Alternatively, or in combination, the thrombectomy device **109** can break apart the thrombus T. For example, when the thrombectomy device **109** includes one or more protrusions, the protrusions can fragment the thrombus T into smaller pieces suitable for aspiration. Fragmentation may be desirable when the thrombus T is too large to be aspirated.

[0106] Further still, aspiration can occur at the opening **201** or a distal opening on the distal face of the thrombectomy device **201**. In some embodiments, aspirating from both the opening **201** and the distal opening advantageously prevents clotting material from moving further downstream after it engages the thrombectomy device **201**.

[0107] The methods of the present technology can be performed under fluoroscopy such that at least some portions of the thrombectomy device can be visualized by a physician to ensure proper placement of the thrombectomy device. For example, the thrombectomy device can include one or more radiopaque portions or markers (e.g., on a distal end of the tubular member). The one or more radiopaque portions can be visualized using fluoroscopy and/or other suitable imaging techniques to assist in positioning the thrombectomy device.

IV. CONCLUSION

[0108] Although many of the embodiments are described above with respect to systems, devices, and methods for treating vessel occlusions in the brain, the technology is applicable to other applications and/or other approaches, such as vessel occlusions elsewhere in the body. Moreover, other embodiments in addition to those described herein are within the scope of the technology. Additionally, several other embodiments of the technology can have different configurations, components, or procedures than those described herein. A person of ordinary skill in the art, therefore, will accordingly understand that the technology can have other embodiments with additional elements, or the technology can have other embodiments without several of the features shown and described above with reference to FIGS. **1**A-**7**C.

[0109] The descriptions of embodiments of the technology are not intended to be exhaustive or to limit the technology to the precise form disclosed above. Where the context permits, singular or

plural terms may also include the plural or singular term, respectively. Although specific embodiments of, and examples for, the technology are described above for illustrative purposes, various equivalent modifications are possible within the scope of the technology, as those skilled in the relevant art will recognize. For example, while steps are presented in a given order, alternative embodiments may perform steps in a different order. The various embodiments described herein may also be combined to provide further embodiments.

[0110] As used herein, the terms “generally,” “substantially,” “about,” and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent embodiments in measured or calculated values that would be recognized by those of ordinary skill in the art.

[0111] Moreover, unless the word “or” is expressly limited to mean only a single item exclusive from the other items in reference to a list of two or more items, then the use of “or” in such a list is to be interpreted as including (a) any single item in the list, (b) all of the items in the list, or (c) any combination of the items in the list. Additionally, the term “comprising” is used throughout to mean including at least the recited feature(s) such that any greater number of the same feature and/or additional types of other features are not precluded. It will also be appreciated that specific embodiments have been described herein for purposes of illustration, but that various modifications may be made without deviating from the technology. Further, while advantages associated with certain embodiments of the technology have been described in the context of those embodiments, other embodiments may also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages to fall within the scope of the technology. Accordingly, the disclosure and associated technology can encompass other embodiments not expressly shown or described herein.

Claims

1. A thrombectomy system comprising: a thrombectomy device including a tubular member having a proximal end region configured to be disposed extracorporeally and a distal end region configured to be disposed at an intravascular treatment site at or adjacent to a thrombus, the tubular member comprising: a sidewall defining a lumen extending therethrough from the proximal end region to the distal end region; and an opening in the sidewall in the distal end region, the opening including a proximal portion spanning a first width and a distal portion spanning a second width greater than the first width; and a suction source configured to be fluidically coupled to the lumen.

2. The thrombectomy system of claim 1, further comprising a cover at least partially overlying the proximal portion of the opening.

3. The thrombectomy system of claim 2, wherein the suction source is configured to displace the cover from the proximal portion of the opening.

4. The thrombectomy system of claim 1, wherein when the suction source is coupled with the tubular member, the suction source applies a greater negative pressure in the distal portion of the opening than in the proximal portion of the opening.

5. The thrombectomy system of claim 1, wherein the proximal portion of the opening spans a first length of the tubular member and the distal portion of the opening spans a second length of the tubular member less than the first length.

6. The thrombectomy system of claim 1, wherein the distal end region of the tubular member comprises a plurality of circumferential struts, the circumferential struts defining the opening.

7. The thrombectomy system of claim 6, wherein the circumferential struts have a greater circumferential width in a proximal section than in a distal section.

8. The thrombectomy system of claim 6, wherein the circumferential struts comprise an upper portion and a lower portion, the upper portion offset longitudinally from the lower portion.

9. The thrombectomy system of claim 6, further comprising a plurality of protrusions extending from the circumferential struts.

10. The thrombectomy system of claim 1, wherein the tubular member further comprises a distal opening on a distal face of the tubular member.

11. A method comprising: disposing a medical device within a vessel at or adjacent a treatment site, the medical device comprising: a tubular member, the tubular member having a side opening in a distal region of the tubular member, wherein the side opening comprises a proximal portion and a distal portion; and applying a negative pressure to the tubular member, wherein the negative pressure is greater in the distal portion of the side opening than in the proximal portion of the side opening for a first time period, and wherein the negative pressure in the distal portion of the side opening is less than or equal to the negative pressure in the proximal portion of the side opening for a second time period after the first time period.

12. The method of claim 11, wherein the medical device further comprises a cover overlying the proximal portion of the side opening.

13. The method of claim 11, wherein, during the first time period, the cover is in a first position, and during the second time period, the cover is in a second position proximal to the first position.

14. The method of claim 11, wherein during the second time period, the cover is at least partially displaced.

15. The method of claim 11, wherein the proximal portion of the side opening occupies a first length of the tubular member and the distal portion of the side opening occupies a second length of the tubular member less than the first length.

16. The method of claim 11, wherein the distal region of the tubular member comprises a plurality of circumferential struts, the circumferential struts defining the side opening.

17. A thrombectomy device comprising: a tubular member having a sidewall defining a lumen extending therethrough from a proximal end region to a distal end region, the tubular member configured to be fluidically coupled to a suction source to supply negative pressure to the lumen; an opening in the sidewall in the distal end region, the opening including a first portion and a second portion; and a rupturable cover extending over only the first portion of the opening such that the second portion of the opening is uncovered.

18. The thrombectomy device of claim 17, wherein the first portion is proximal to the second portion.

19. The thrombectomy device of claim 17, wherein the first portion has a smaller width than the second portion.

20. The thrombectomy device of claim 17, wherein the first portion has a longer axial length than the second portion.