CLAIMS

1. A catheter for treating an occlusion in a body lumen, the catheter comprising:

a catheter body having a distal end, the catheter body being fillable with a fluid;

an impactor connected to the distal end of the catheter body, the impactor having a proximal end inside the catheter body and a distal end outside the catheter body;

a shock wave source configured to generate a shock wave; and

a deflector coupled to the proximal end of the impactor in between the shock wave source and distal end of the catheter body, wherein, when the shock wave source generates a shock wave, the shock wave impinges on the deflector causing the deflector to advance in a forward direction in conjunction with the impactor such that the distal end of the impactor delivers a mechanical force to the occlusion.

2. The catheter of claim 1, wherein the distal end of the catheter body comprises a flexible material that permits the impactor to advance in a forward direction responsive to generation of a shock wave and causes the impactor to return backward after the shock wave has terminated.

3. The catheter of claim 1, wherein the fluid is a conductive fluid, and wherein the shock wave source includes an electrode pair.

4. The catheter of claim 3, further comprising:

a first insulated wire extending along a length of the catheter, the first insulated wire having an exposed distal tip; and

a second insulated wire extending along the length of the catheter, the second insulated wire having an exposed distal tip;

a conductive emitter band mounted within the catheter and surrounding the exposed distal tips of the first and second insulated wires; and

wherein, when a voltage is applied across the first insulated wire and the second insulated wire, a current is configured to flow from the exposed distal tip of the first insulated wire to the conductive emitter band to generate a first shock wave, and wherein the current is further configured to flow from the conductive emitter band to the exposed distal tip of the second insulated wire to generate a second shock wave.

5. The catheter of claim 3, further comprising a voltage source configured to deliver high voltage pulses to the shock wave source, wherein the high voltage pulses are between 100V and 3000V.

6. The catheter of claim 5, wherein the voltage source is configured to deliver the voltage pulses at a rate of 10Hz to 100Hz.

7. The catheter of claim 1, wherein, when the shock wave source generates a shock wave, the deflector is configured to advance between 50 μm and 100 μm.

8. The catheter of claim 1, wherein, when the shock wave source generates a shock wave, the deflector deflects a portion of shock wave energy in a direction transverse to the catheter.

9. The catheter of claim 1, wherein a deflector angle between the back surface of the deflector and a longitudinal axis of the catheter body is between 120° and 150°.

10. The catheter of claim 1, further comprising:

a cylinder mounted within the catheter body; and

a shaft mounted to a proximal end of the deflector, wherein the shaft is configured to slide within the cylinder.

11. The catheter of claim 10, wherein the shaft comprises a spacer that projects outward between the shaft and the cylinder to retain the shaft at approximately a center of the cylinder while permitting movement of the shaft along a central axis of the catheter.

12. The catheter of claim 1 wherein the shock wave source includes a laser generating pulses of light, said pulses of light being delivered to the catheter body via an optical fiber.

13. The catheter of claim 1, wherein the impactor includes a laser-cut metal tube.

14. The catheter of claim 13, wherein the impactor includes a guide wire lumen sized to receive a guide wire.

15. The catheter of claim 1, further comprising a tapered distal tip coupled to the distal end of the catheter body, wherein the tapered distal tip is configured to advance in a forward direction in conjunction with the deflector and the impactor to deliver a mechanical force to the occlusion.

16. The catheter of claim 15, wherein the tapered distal tip comprises a rigid material.

17. The catheter of claim 1, wherein the catheter body comprises a plurality of folds disposed on the catheter body, the plurality of folds configured to expand to an unfolded position in response to generation of a shock wave and to return to a folded position after the shock wave has terminated.

18. The catheter of claim 17, wherein the catheter body comprises a vibrating section in between the folds and the distal end of the catheter body and a stationary section located on a proximal end of the catheter body that terminates at the folds; and wherein the vibrating section is configured to move in the forward direction as the folds expand to the unfolded position and to return backward when the folds return to the folded position.

19. The catheter of claim 1, wherein the shock wave source comprises

a cylindrical inner conductive sheath mounted within the catheter, the inner conductive sheath having a distal side edge;

a cylindrical outer conductive sheath mounted circumferentially around the inner conductive sheath within the catheter, the outer conductive sheath having a distal side edge proximal to the distal side edge of the inner conductive sheath; and

an insulation sheath mounted within the catheter between the outer conductive sheath and the inner conductive sheath;

wherein, when voltage pulses are applied across the inner conductive sheath and the outer conductive sheath, current flows across an arcing region between the inner conductive sheath and the outer conductive sheath to generate shock waves.

20. The catheter of claim 1, wherein the shock wave source comprises:

a cylindrical conductive sheath mounted within the catheter, the conductive sheath having a distal side edge;

an insulation sheath mounted circumferentially within the conductive sheath, the insulation sheath having a distal side edge proximal to the distal side edge of the conductive sheath;

a flat coil disposed on an inner surface of the insulation sheath and the distal side edge of the insulation sheath; and

wherein when voltage pulses are applied across the flat coil and the conductive sheath, current flows in an arcing region between the flat coil and the conductive sheath to generate shock waves.