This invention relates to apparatus for local temperature change of organs of the body including cooling thereof to reduce their requirement for oxygen and to lessen the tendency of injury to sensitive tissue when the blood supply to the organ is occluded.

In various surgical procedures generalized hypothermia is sometimes used where the entire body of the patient is reduced in temperature to reduce the metabolic requirements and permit the occlusion of various arteries supplying body organs. However this general hypothermia may be accompanied by cardiac standstill and irregularities occurring at lower temperatures with attendant lessening of the safety of the operative procedure and the length of time during which the surgical procedure may be carried out.

Some suggestions have been made of localized hypothermia but these have involved the use of inefficient and bulky units which have not successfully lowered the temperature of the organ worked on to the desired degree and have not provided the necessary field for visual operative procedure.

It is the object of this invention to provide apparatus for the local cooling or warming of body organs which is of minimum size and maximum efficiency in the heat exchange operation to effect the desired change in temperature of the organ being worked on.

Another object of the invention is an apparatus for the cooling or warming of body organs in accordance with the preceding object which is formed of double walled sheet metal sections through which a heat exchange fluid is circulated, with the sections when assembled having an interior formation conforming to the exterior shape of the organ to be cooled.

Another object of the invention is an apparatus for local temperature change of a body organ in accordance with the immediately preceding object in which the sections may be moved as desired to uncover portions of the organ for surgery or other manipulation.

Another object of the invention is apparatus in accordance with each of the preceding objects in which the exterior surface of the organ enclosure is coated with a heat insulating material tending to insulate the organ under manipulation from the normal body temperature.

A still further object of the invention is apparatus in accordance with each of the preceding objects in which a heat conducting cushion is interposed between the organ and the enclosure about the organ, through which the heat exchange to the organ is effected and with the cushion compensating for variation between the size and shape of the organ and the interior conformation of the enclosure.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawing illustrating certain preferred embodiments in which:

FIG. 1 is a front view of an apparatus for heat transfer according to the present invention, enclosing a human kidney;

FIG. 2 is a side elevational view of the apparatus of FIG. 1;

FIG. 3 is a sectional view on the line 3-3 of FIG. 1;

FIG. 4 is a view similar to FIG. 1 but showing a section of the apparatus opened out to uncover a portion of the enclosed organ; and

FIG. 5 is a schematic view showing the circulation of the heat transfer fluid.

As specifically shown in the figures, the heat transfer enclosure of the invention is illustrated in a size and form to accommodate a human kidney as it will be enclosed for operation thereon on the kidney artery or in certain types of abdominal surgery.

The enclosure is specifically illustrated at 1 as including a back half section 2 and a pair of front quarter sections 3 and 4 cooperating therewith to encapsulate the kidney. The sections are provided with an opening 5, in their righthand edges as viewed in FIG. 1, through which extend the body conduits attached to the kidney such as a ureter 6, a renal artery 7 and a renal vein 8. The kidney itself is shown at 9 in FIG. 3 disposed within the sections 2, 3 and 4 but separated therefrom by a cushion 11 which may be in as many sections as desired and which accommodates for dimensional differences in size and shape between the kidney and the interior conformation of the enclosure. The cushion section or sections 11 are preferably of surgical sponge material and saturated with a heat conducting liquid such as a saline solution to encourage heat transfer between the kidney and the enclosure sections.

The sections 2, 3 and 4 are formed of double thin wall sheet metal, such as stainless steel, so as to reduce the bulk of the kidney enclosure to facilitate the carrying out of the surgical procedure with a minimum of obstruction in the surgical field. They are composed of an inner wall 12 of smooth configuration and shaped to conform to the shape and size of the kidney or other organ with which heat transfer is to be had. To accommodate kidneys of varying sizes, the sections may be made in a plurality of sets to encompass rather closely the range of kidney sizes which occur in the human body. To the inner sheet metal wall 12 is attached an outer sheet metal wall 13, joined thereto at the edges by brazing or welding, and with the outer wall 13 provided with a plurality of interiorly directed ridges 14 engaging the inner wall 12 and also brazed or welded thereto. The ridges 14 stop short of the edges of the walls so as to form interconnected passageways 16 between the inner and outer walls through which the circulation of the heat transfer fluid therethrough.

Section 3 is provided with a pair of tubes 15 and 16 communicating with the passageway 16 between its inner and outer walls 12 and 13 and the section 4 is similarly provided with a pair of communicating tubes 17 and 18. The passageway 10 within the section 2 is provided with a pair of communicating tubes 19 and 21. The tubes 16 and 17 are connected by flexible tubing 22 and the tubes 15 and 19 by flexible tubing 23. The tubes 18 and 21 are connected to a source of heat transfer circulating fluid by tubing 24 and 25.

This circulatory system is shown schematically in FIG. 5 in which a block element 26 represents a refrigerator or heater for the circulating fluid with a pump 27 for effecting circulation and a valve 28 for controlling the rate of flow. The circulating fluid may be water or for lower temperatures may be a water-glycol mixture.

To insulate the heat transfer fluid within the passageways 10 from normal body temperature the enclosure sections 2, 3 and 4 are provided on their exterior surfaces with an insulating coating 29 such as an epoxy resin.

To hold the sections together in assembled relation, they are provided with mating eyelet openings 30 through which is threaded and tied surgical thread 32 which will hold the sections in assembled relation when desired and which may be readily untied or cut to permit the disassembly or swinging out of place of any or all of the sections.

As viewed in FIG. 4, section 3, as shown in full lines, has been united at two of its sets of mating eyelets and
has been swung approximately 90° in a counterclockwise direction to the left to uncover the quarter section of the kidney 9 therein disclosed. In thus uncovering the kidney section for surgical procedures, the cushion 11 may be folded back or cut off as desired. In any event only that portion of the kidney or other organ on which a manipulation is to be effected need have the cooling enclosure removed therefrom. The dotted line portion of FIG. 4 indicates the swinging of the section 3 toward the right in a clockwise direction where this will better facilitate the opening of the operative field.

In the use of the apparatus for hypothermia or cooling of the enclosed organ the cooling fluid may be circulated at a temperature, for example, of 20° F. with a lowering of the kidney temperature to a region of 55°–62° F. It will be understood, of course, that these values are approximate and in no way critical but are given as representative of one desired condition.

In the cooling operation it will be further understood that before surgery is performed the normal procedure will be to occlude the renal artery 7 to cut off flow of blood to the kidney after its temperature has been lowered to the point where its oxygen requirements are materially reduced.

As specifically illustrated in the drawing, the assembled apparatus is made up of three sections, a half section 2 and quarter sections 3 and 4. With this arrangement any quarter section of the kidney on which a manipulation is desired can be exposed in the surgical field while maintaining the remainder of the organ in contact with the heat exchange apparatus. If the entire end of the kidney is desired to be exposed for surgery thereon, then two quarter sections may be utilized to enclose the opposite end of the kidney. By various combinations of quarter sections any desired surgical field on the kidney may be exposed for manipulation.

While this invention has been described with particular reference to hypothermia and the lowering of the temperature of the body organ to permit the occlusion of the blood supply thereto for longer periods of time without injury, it will be understood that the apparatus also lends itself to the local application of heat to an enclosed organ by circulating a heat transfer fluid at the proper temperature through the organ enclosure, and while certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation consistent with the prior art.

What is claimed is:

Apparatus for local temperature change of a body organ comprising complementary sections which when assembled have an interior surface formation conforming to the exterior shape of said organ for enclosing the same, each of said sections being formed of double, thin, sheet metal walls connected at their edges and at portions therebetween and spaced apart to form passageways for the circulation of a heat transfer fluid therethrough, the juxtaposed edges of said sections being shaped to provide an opening therethrough for the passage of body conduits attached to said organ when the same is enclosed by said assembled sections, a thermally insulating coating on the exterior surfaces of said sections to insulate the heat transfer fluid from normal body temperature, flexible tubing means interconnecting the passageways in said sections to permit independent movement of said sections to uncover portions of said organ as desired, means for circulating a heat transfer fluid through said passageways and interconnecting means, and a heat conducting cushion of sponge material mounted on the interior surface of the assembled sections to compensate for variations between the size and shape of the organ and the interior conformation of said sections.

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