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# Interposed abdominal compression cardiopulmonary resuscitation: Are we missing the mark in clinical trials?

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## **ABSTRACT**

Straightforward considerations of abdominal anatomy in human beings set tight constraints on the theoretically optimal technique for abdominal compressions during interposed abdominal compression (IAC)-CPR. The location and extent of the abdominal aorta lead naturally to the recommendation that IAC be applied at a level corresponding to the lower two thirds of the sterno-umbilical line. The force vector required to achieve contact compression of the abdominal aorta is inclined in the transverse plane at an angle of 11 degrees from the vertical toward the left. Such slightly angled compression subjects the abdominal aorta to maximally flattening; while the inferior vena cava on the right is sheltered somewhat from direct compression by the crest of the spine. Physics suggests that the optimal pressure for IAC is the same as the contact pressure required to best palpate the abdominal aortic pulse. Constraints of human anatomy also suggest an optimal posture for the rescuer applying IAC. A straight-arm technique from the left side is less tiring, so that the weight of the torso and a rocking motion can be used. Placement of the rescuer's knees close to the victim's side will help to support most of the rescuer's weight and so avoid overly forceful abdominal compression. The proposed left-sided, angled technique for selective aortic compression is easy to teach, to remember, and to apply with minimal fatigue.

**Key words:** hand position, IAC-CPR, technique

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Recent clinical studies have highlighted the potential efficacy and consistent safety of manually interposed abdominal compression (IAC) as a promising adjunct to otherwise standard cardiopulmonary resuscitation (CPR).<sup>1-4</sup> Over 14 laboratory and clinical studies, previously reviewed,<sup>3, 5, 6</sup> have shown the beneficial effects of IAC-CPR, which essentially doubles blood flow, systemic perfusion pressure, and short-term survival when compared with standard CPR. In one prospective randomized trial involving 103 patients resuscitated in-hospital with either IAC-CPR or standard CPR, long-term survival to discharge was 25 % for those resuscitated with IAC-CPR compared with only 7% for those resuscitated with standard CPR. A few notable exceptions have been reported, however, suggesting that IAC is not uniformly efficacious. These include a small series of patients studied by McDonald,<sup>7</sup> a prehospital clinical trial by Mateer et al.,<sup>4</sup> and a comparison of various external CPR methods in animals by Kern et al.<sup>8</sup> The current status of IAC-CPR suggests clear promise for the technique in general together with a need for further optimization and inspired the First Purdue Conference on IAC-CPR, October 24-25, 1992, at which active investigators studying IAC-CPR reviewed the state of the art and discussed future research directions.

For me as conference chairman, the most surprising and informative sessions were the practical demonstrations. These sessions, in which those assembled described and demonstrated the various techniques of IAC under investigation in current clinical studies, revealed a complete lack of uniformity in the precise mechanics by which abdominal compressions are being applied at various institutions. The alternative methods presented both for previously reported studies and for unpublished work in progress included (1) central abdominal compression centered over the umbilicus with over-and-under hand position similar to that used for chest compressions in standard CPR, (2) epigastric compression with over-and-under hand compression; (3) left paramedian compression with side-by-side hand position, one hand caudal and one hand cranial to the umbilicus; (4) broad abdominal compression centered over the umbilicus with approximated open hands, thumbs together, and fingers widely spread; and (5) broad, central abdominal compression with a hard-cover book to distribute the force uniformly over the anterior abdominal wall.

Clearly, to obtain consistent results the members of the involved research community will need to determine the most safe and effective single technique for the application of IAC before further multicenter clinical trials are undertaken. On reflection, and with reference to widely available standard sources, I have concluded that straightforward considerations of abdominal anatomy in human beings set extremely tight constraints on the theoretically optimal IAC technique, which is substantially different from all of the methods (1 to 5 above) previously described. In particular, the use of an anatomically realistic means that to selectively compress the abdominal aorta by IAC is quite possible and quite likely to improve the quality and consistency of future research. Recognition of the relevant anatomic realities may also explain the lack of significant differences between standard CPR and IAC-CPR that have been reported in a minority of published studies--possibly because the manual techniques used failed to selectively compress the abdominal aorta. This article provides an analysis of the relevant anatomic constraints and suggests guidelines that are likely to maximize both the efficacy and the safety of IAC-CPR.

The starting point for this analysis is the consistent and compelling preclinical research, which indicates that a major mechanism by which IAC enhances artificial circulation is compression of the abdominal aorta.<sup>9-13</sup> It is generally agreed that the effects of external manual compression are in large part analogous to those of an intra-aortic balloon pump, forcing blood from the aortic pressure/volume reservoir into the periphery against a closed and competent aortic valve.<sup>6, 12, 14</sup> During the release phase of abdominal compression, which is simultaneous with the active phase of chest compression during IAC-CPR, the aorta fills from the left ventricle and the cycle begins anew. Abdominal venous compression may also play a role in augmentation of cardiac output through improved filling of the right heart and thoracic pump mechanism<sup>15, 16</sup>; however, for maximal augmentation of systemic and coronary perfusion pressures, it is clearly necessary for the IAC-induced pressure rise in the thoracic aorta to be greater than the corresponding IAC-induced pressure rise in the right atrium. Accordingly, it is reasonable to assume that abdominal aortic compression is crucial for success of the technique—especially in generating positive coronary perfusion pressure, which in turn is a known crucial determinant of the return of spontaneous circulation after all but momentary episodes of cardiac arrest.<sup>17-20</sup>

### **Contact compression versus hydrostatic compression.**

Local external compression of structures within a gas- and fluid-filled space such as the human abdomen can be considered to have two major components: contact compression and hydrostatic compression. In IAC-CPR, contact compression occurs to the extent that the localized external force applied to the abdominal wall is directly transmitted through intervening tissues to underlying structures such as the aorta and great veins. Hydrostatic compression occurs to the extent that a general rise in intra-abdominal pressure is created and transmitted uniformly to all sides of intra-abdominal structures. Because the aorta is fundamentally stiffer than the inferior vena cava and other intra-abdominal veins, it follows that IAC alone cannot elevate central arterial pressure maximally unless there is contact compression of the aorta. For maximal benefit of abdominal counterpulsation, that is, for maximal aortic “stroke volume,” the abdominal aorta must be compressed locally to an average luminal diameter or cross-sectional area that is smaller than its resting, unstressed diameter during cardiac arrest. In turn, maximal aortic stroke volume requires external compression that overcomes the stiffness of the aortic wall. If only generalized hydrostatic compression of the abdominal vessels occurred during cardiac arrest, the stiff wall of even a non-diseased aorta would resist such compression more than the compliant walls of intra-abdominal veins, and central venous pressure at that point would tend to rise more than thoracic aortic pressure. Maximal augmentation of coronary perfusion pressure, therefore, requires maximal aortic stroke volume and in turn selective contact compression of the abdominal aorta.

Assuming, then, that the goal in IAC-CPR is to maximally compress the abdominal aorta with minimum risk to other vital viscera, a simple review of the relevant human anatomy, which is both well described and readily available from routine computed tomographic (CT) scans<sup>21, 22</sup> provides a number of telling insights that have not heretofore been described in the literature of IAC-CPR. These realities of abdominal anatomy impose surprisingly tight geometric limits on optimal IAC technique, when optimal IAC is defined in terms of the location and direction of the force vector, which, when applied to the abdominal wall by the rescuer’s hands, is most likely to compress the abdominal aorta directly while subjecting the majority of intra-abdominal veins to hydrostatic compression only. Moreover, the additional limitations of rescuer anatomy also

suggest a simple and perhaps unique posture from which IAC can be best applied to a victim in the usual supine position.

### **The cranial-caudal dimension.**

Cross-sectional images of the human abdomen, obtained either from fixed cadavers or from CT scans,<sup>21, 22</sup> clearly reveal that the abdominal aorta bifurcates at the level of the umbilicus, which is normally equivalent to the intercrystal transverse plane through the iliac crests.<sup>23</sup> Accordingly, IAC techniques centered on the umbilicus, especially those techniques involving large areas below the umbilicus, are likely to be only partially effective in achieving contact compression of the abdominal aorta itself. To achieve direct contact compression of the abdominal aorta, the best site for IAC should be headward of the umbilicus--somewhere between the intercrystal plane and the tip of the xyphoid process. In practice, the proper level for IAC is further constrained because the rectus and oblique muscles are tethered to the tapering costal margins superiorly, where they tend to impede effective IAC applied in the immediate subcostal third of the sterno-umbilical line, extending from the xyphisternal junction to the umbilicus. These anatomic features lead naturally to the recommendation that IAC be applied at a level corresponding to the lower two thirds of the sterno-umbilical line, a zone also denoted by the bony landmarks of the iliac crests inferiorly and by the lateral costal margins superiorly.

Concerns of safety also serve to constrain the cranial-caudal coordinate for optimal IAC to the lower or caudal two thirds of the sterno-umbilical line. Because the left lobe of the liver and the head of the pancreas lie deep to its upper third beneath the xyphoid process, IAC applied “too high” would be more likely to induce the possible complications of either liver laceration or traumatic pancreatitis than IAC applied just superior to the umbilicus. (In the approximately 400 patients resuscitated with IAC-CPR to date, only one pediatric case has been reported associating IAC-CPR with abdominal visceral injury,<sup>24</sup> which in this case involved the pancreas.) This leaves a span of only about 8 to 9 cm cranial to the intercrystal plane at the umbilicus, a distance equal to the width of a medium-sized adult hand.<sup>25</sup> In this manner, I suggest that the cranio-caudal coordinate for optimal IAC can be deduced from anatomic considerations alone.

### **The right-left dimension and angle of compression.**

Again, assuming that the physiological objective is to create selective contact compression of the abdominal aorta together with predominantly hydrostatic compression of abdominal veins, analysis of cross-sectional anatomy and CT scans (Fig. 1) suggests similarly tight constraints on the right-left coordinates of the most desirable compression zone. Seen in cross-section in the supine patient, the abdominal aorta lies on the vertebral crest, very nearly in the midline, but typically one fourth to one half aortic diameter--or about 1 cm--to the left. A notable feature of abdominal anatomy in this context is that the aorta is elevated on a bony pedestal of the lumbar spine and in this position is more susceptible to direct compression through the anterior body wall than more lateral structures. The most obvious and direct means of contact compression is by application of a force vector which, if extended through the body, would traverse the central axis of the aorta at an angle perpendicular to the surface of the vertebral column. Such a force would most effectively tend to flatten the aorta against the spine, which is tethered in position by retroperitoneal fascia and the emerging segmental arteries. In contrast, the overlying loops of

bowel are more free to move in response to applied manual compression and so are likely to avoid repeated entrapment against the spine.

Analysis of eight normal transverse CT scans of the abdomen depicted in standard textbook examples<sup>21, 22</sup> shows that the force vector required to achieve such direct contact compression at the target cranio-caudal levels approaches the aorta from the anterior abdominal wall just left of midline and is inclined in the transverse plane at a mean angle of 11 degrees from the vertical, with a range of 8 to 14 degrees (Fig. 1). This compression angle is only a slight departure from the vertical and can be visualized as one quarter of a familiar 45-degree angle. Similar analysis of cross-sectional anatomy for non-obese subjects reveals that the path of the ideal force vector for aortic contact compression intersects the skin surface approximately 3 cm leftward of the midline (range 2.7 to 4.1 cm): In relative terms the proposed optimal compression point averages 19 percent, or about one fifth, of the distance from the midline to the lateral edge of the abdominal wall. The slightly angled compression subjects the abdominal aorta to maximal flattening; while the inferior vena cava on the right is sheltered somewhat from direct compression by the crest of the spine.

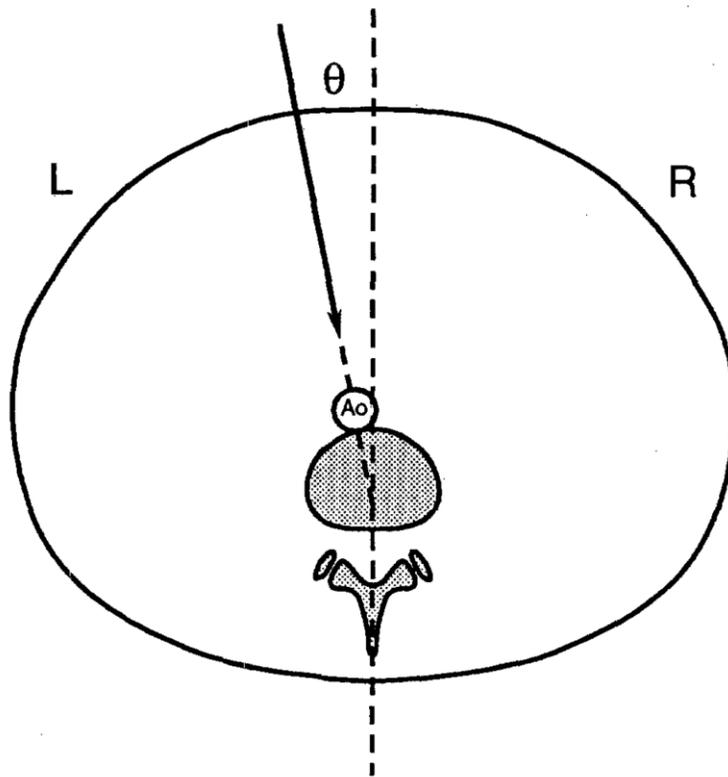


Fig. 1. Relationships of aorta (Ao), spine, and body wall two finger-breadths above the intercrystal plane. Redrawn from reference 21. Abdominal aorta rests near crest of spine, with its longitudinal axis one fourth to one half aortic diameter to left of midline. Angle ( $\theta$ ) of the force vector most likely on anatomic grounds to compress aorta directly against spine, is shown with respect to median sagittal plane. L, Left; R, right.

These anatomic considerations fix the site and direction of abdominal compression vector in three dimensions. The cranio-caudal coordinate is one third of the distance between the level of the umbilicus, or intercrystal plane, and the level of the xyphisternal junction. The right-left coordinate is one fifth the distance from the umbilicus to the lateral abdominal margin, or 3 cm to the left of midline; the direction of force is perpendicular to the long axis of the aorta in the sagittal plane and 11 degrees from the vertical in the transverse plane. For obese subjects, the right-left coordinate of the compression point on the skin surface must be a further absolute distance from the midline to maintain the nominal 11 degree angle.

When projected from the skin surface to the aorta, the path of the force vector just described traverses the transverse colon, loops of small bowel, and the superior mesenteric vessels. This left-of-midline approach exploits the asymmetries of abdominal anatomy to avoid contact compression of the lower pole of the left kidney, which is typically more cranial than that of the right kidney; the left lobe of the liver, which is always more cranial than the right lobe of the liver; and the tail of the pancreas, which is more cranial than the head of the pancreas. These parenchymal organs are more susceptible to blunt trauma than the transverse colon or small intestines and so would be best avoided in larger scale clinical trials of IAC-CPR.

### **Validation through inverse solution of the optimal IAC problem.**

The validity of these spatial coordinates for the most direct vector from the skin surface to the abdominal aorta can be tested by any reader through simple self-examination. While sitting at my desk I can readily palpate my own aortic pulse from the starting point and angle just described. (How startling it was the first time I tried this maneuver to realize that I had been working on IAC-CPR for over 10 years and had never done it before!) One effective technique seems to be with the fingertips of the right and left hands together, with well-trimmed fingernails of opposite hands touching. Alternatively, a two-handed technique with the fingertips of the left hand overlying those of the right may be used. A stronger aortic pulse can be felt lying in the supine position, especially just before rather than just after a meal, because food in the pyloric antrum can somewhat obscure the palpation of the aortic pulse. By using as little as 5 cm of painless compression with the opposing fingertips, the aortic pulse can be readily appreciated. With one additional centimeter of compression the pulse becomes very strong, and with deep pressure a thrill can be appreciated. If the bell of a stethoscope is pressed hard in the direction just described, a murmur is created that can be heard through the stethoscope, providing evidence of turbulent flow consistent with compression of the abdominal aorta by an external, manual technique.

This simple maneuver for self-palpation of the abdominal aorta represents an inverse solution to problem of defining optimal IAC. If in the engineering sense<sup>26</sup> the “forward problem” is considered to be that of characterizing in terms of surface location and angle the vector of manual force which, when applied to the surface of the/abdomen, causes the most effective contact compression of the aorta, then the “inverse problem” can be stated as that of characterizing in terms of surface location and angle the hand position at which the pulse is most effectively transmitted in the opposite direction from the aorta to the palpating fingers. The forward problem can, and probably will, be solved by laboratory and clinical experiments in

which hemodynamics during IACCPR are measured during a variety of compression techniques. The inverse problem can be solved by methods as simple as physical examination, which can be duplicated by medical personnel anywhere, and which may in the future provide training tools of great value.

### **The hand and body position of the rescuer.**

Assuming that a slightly angled, left paramedian compression vector is most desirable for IAC-CPR, the constraints of human anatomy also suggest an optimal way for a rescuer to apply such a force, angled slightly from the left toward the midline. First, the rescuer should approach the abdomen from the left side. To my knowledge, no previously published protocol on IAC technique has specified from which side IAC should be performed. The position of the stick figure shown in Fig. 2, A seems naturally and perhaps uniquely suited to optimal IAC-CPR in settings where both rescuer and victim are at ground level. Because of the limited 8 to 10 cm extent of the lower two thirds of the sterno-umbilical line, over-and-under rather than side-by-side hand position is clearly required.

A particularly natural and teachable version is shown in Fig. 2, B: right hand on the abdomen, thumb extended and pointing toward the victim's feet, and the umbilicus in the apex of the thumb-index angle. (For obese victims the right hand can be placed just headward of the intercrystal plane and moved laterally to maintain the proper angle so that the umbilicus lies opposite the knuckles). The left hand is placed over the right in a manner similar to that used for chest compression. Compression is applied through the right wrist and heel of the right hand only, supported by the left. The fingers curl upward slightly, and the fingertips rest gently on the abdomen, not to apply force, but only to steady the position of the hands. Contact is made through the hypothenar and thenar pads of the right hand and the through the fingertips (shaded areas in Fig. 2, B). This relatively small contact area minimizes direct compression of veins and also minimizes any generalized, hydrostatic rise in intra-abdominal pressure that would be transmitted to veins. Note that the effects of this approach physiologically are opposite those of side-by-side, spread hands techniques, which tend to maximize hydrostatic compression of veins and to minimize contact compression of the aorta.

A straight-arm technique is less tiring, so that the weight of the torso and a rocking motion can be used to apply IAC. 'This position is easily practiced on a normal volunteer in whom the aortic pulse can be well appreciated, because the aorta is minimally compressed against the spine without significant discomfort to the volunteer in a manner analogous to palpation of the aortic pulse during routine physical examination of the abdomen. To maintain the desired 10- to 12-degree angle of the straight arms with respect to the vertical, the rescuer need only maintain his or her chin over the wrists. This rule follows from human geometry, since adult wrist-shoulder distance is about 80 cm, the mean chin-shoulder distance is about 15 cm, and the arcsine (15/80) equals 11 degrees. Placement of the rescuer's knees close to the victim's side will help to support most of the rescuer's weight and so avoid overly forceful abdominal compression.

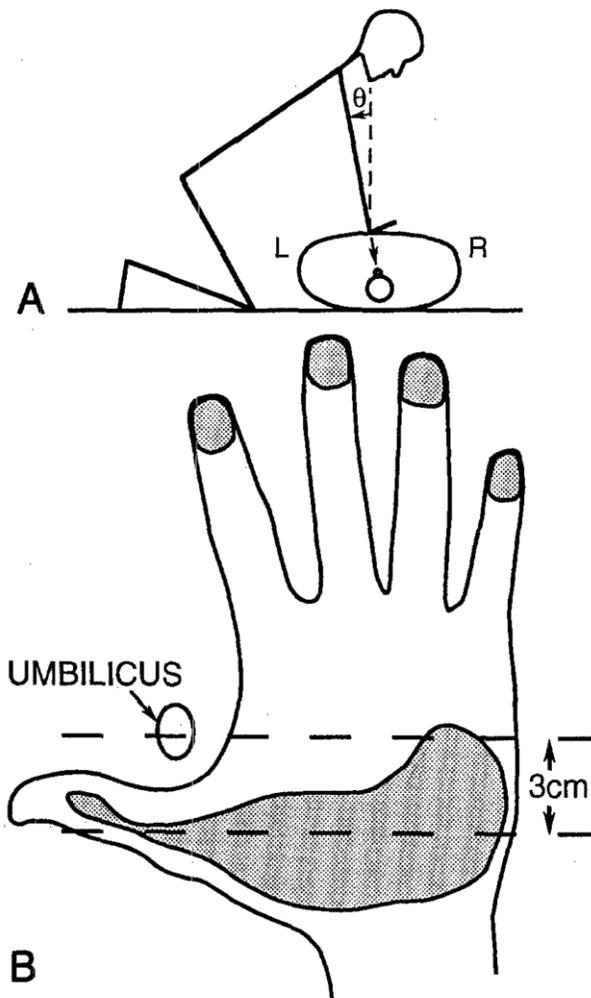


Fig. 2. A, Natural position of rescuer and victim for proposed anatomically optimal transcuteaneous compression of abdominal aorta: rescuer kneels on victim's left side, weight toward heels, and extends straight arms to apply IAC. When chin is over wrists, angle of compression is approximately 11 degrees from vertical. B, Rule of thumb for locating best compression point on abdominal wall by rescuer kneeling at victim's left side. In non-obese subjects, right hand is positioned so that the umbilicus appears in thumb-index angle, with thumb pointing toward feet. Heel of right hand is centered approximately 3 cm left of midline, overlying abdominal aorta above its bifurcation. Shaded areas indicate direct contact between right hand and abdominal wall when fingers are slightly curved to minimize contact compression of inferior vena cava on victim's right side. For obese subjects, cranial-caudal level is judged with respect to bony landmark of left iliac crest; heel of right hand is moved laterally so that umbilicus lies opposite knuckles. L, Left; R, right.

## **An inverse solution for the optimal force of IAC.**

There remains only the question as to how hard should the push on the abdomen to create effective contact compression of the abdominal aorta with minimal risk of injury. Once again, I suggest that a simple inverse solution to the problem is available that is anatomically and physiologically valid and readily adapted to the training of medical personnel. The key insight is provided by the work of Geddes et al.<sup>27, 28</sup> who studied the pulse-induced oscillations in cuff pressure that occur during routine clinical measurements of brachial artery blood pressure by the auscultatory method. They found that the counter pressure exerted by the inflatable cuff on an artery at the time of maximum cuff pressure oscillations corresponds closely to mean arterial pressure. To generalize this concept, it is clear that if a pulsating artery is subjected to an external pressure ( $P_o$ ), the maximal radial motion of the vessel wall with each arterial pulse will occur when  $P_o$  is between the systolic and diastolic values of the time-varying internal artery pressure ( $P_i$ ). In particular, during the early systolic phase of the arterial pulse wave,  $P_i$  will be greater than  $P_o$ , and the vessel wall will expand radially outward. During the later diastolic phase of the arterial pulse wave,  $P_i$  will be less than  $P_o$ , and the vessel wall will collapse radially inward. In the case of the arm-and-cuff system, this radial wall motion of the brachial artery produces cuff pressure oscillations.

This same physical concept, however, can be applied to manual transcutaneous compression of the abdominal aorta. If gentle IAC-like, left paramedian compression of the abdomen is applied to a normal subject and the force is gradually increased until a maximal palpable aortic pulse is appreciated, it is reasonable to conclude that the pressure so generated at the adventitial surface of the aorta is equal to the mean intraluminal pressure. Under this test condition radial wall motion, and in turn the palpable aortic pulse, will be greatest, and adventitial pressure on the aorta will be approximately 95 mm Hg (normal mean aortic pressure). This value is reasonable for aortic counterpulsation during CPR, because aortic blood pressure ( $P_i$ ) during CPR is rarely greater than 95 mm Hg; therefore  $P_o$  values equal to normal mean aortic pressure should be sufficient to cause effective external counterpulsation. This value of adventitial periaortic pressure is also close to that required to produce maximal aortic emptying during IAC-CPR in theoretical electronic models of the circulation.<sup>9</sup>

Thus as luck would have it, there is a simple way for two properly trained individuals, by practicing on each other, to learn kinesthetically an effective, near optimal degree of manual force for IAC during CPR. If desired, a folded blood pressure cuff, placed between the compressing hands and the abdomen, can be used to monitor both applied pressure and pulse oscillations during training. My colleague William E. Schoenlein and I have practiced this inverse solution approach to gauging proper force during IAC by using a water-filled pediatric blood pressure cuff 10 cm wide and folded once to make a 9 x 10 cm rectangle. The cuff was connected to a solid-state pressure transducer, and cuff pressure and its amplified oscillations (bandpass filtered 0.3 to 30 Hz) were recorded on a strip chart recorder. As steady manual pressure was gradually increased by using the technique sketched in Fig. 2, recorded pulsations typically increased to a maximum and then declined. Coupling of pressure from the skin surface to the aorta was remarkably efficient with maximal pulsations being felt and recorded with skin surface pressures in the range of 70 to 130 mm Hg. Objectionable discomfort occurred only at

surface compression pressures in excess of 130 mm Hg. The mean abdominal surface compression pressure for maximal aortic pulse oscillations in 14 trials was 94 mm Hg (SEM 5 mm Hg). The value of mean brachial artery pressure, estimated as diastolic pressure plus one third pulse pressure, determined by the usual auscultatory method under the same conditions, was also 94 mm Hg (SEM 1 mm Hg). Logically, if at the time of maximal oscillations periaortic pressure equals mean arterial pressure and abdominal cuff pressure equals mean arterial pressure, periaortic pressure must have equaled abdominal cuff pressure even though we did not measure periaortic pressure directly. These preliminary findings suggest that transcutaneous contact compression of the abdominal aorta can be readily achieved and that the surface pressure created by manual abdominal compression via the route depicted in Fig. 2 is transmitted to the aorta with negligible loss.

### **Conclusions and recommendations.**

In previous work the exact mechanical technique of interposed abdominal compression during CPR has been relatively ill defined, and various research teams have adopted differing approaches and styles of abdominal compression that have yielded generally positive but mixed results. If it is assumed that the physiologic goal of IAC is to achieve contact compression of the abdominal aorta, accompanied by lesser hydrostatic compression of intra-abdominal veins, then the exact site, direction, and contact area of manual abdominal compression become important.

The technique just deduced from anatomic considerations is based on the assumption that IAC should be directed so as to compress the aorta against the spine with minimal risk of traumatic injury to the left lobe of the liver, left kidney, or head of the pancreas. Other approaches may fail or give inconsistent results owing to hit-or-miss aortic compression. For example, if IAC were inadvertently applied at an angle from the right side, causing strong contact compression of the inferior vena cava but not the aorta, augmentation of right atrial pressure would likely be greater than augmentation of arterial pressure. If IAC were applied broadly in the ventral-dorsal dimension with the spread-hands technique, it is likely that relatively uniform hydrostatic compression with minimal contact compression of intra-abdominal structures would occur.

Such variations in technique may explain the results of two prior clinical studies in which no difference was noted in systemic perfusion pressure or survival between IAC-CPR and standard CPR. In the first,<sup>7</sup> "One hand was placed flat in the epigastrium with fingers extended. The other hand was placed on top of it at an approximately 90 degree angle, also with the fingers extended." In the second,<sup>4</sup> the abdomen was compressed "with approximated open hands, centered over the umbilicus," with an air-filled rubber bladder placed between the hands and the abdomen. Both of these spread-hands techniques of abdominal compression probably tended to generate a relatively larger proportion of uniform hydrostatic compression of intra-abdominal vessels rather than selective contact compression of the abdominal aorta. In contrast, the technique of Sack et al.<sup>1</sup>, as demonstrated at the First Purdue Conference on IAC-CPR and in Fig. 2 of reference 1, included application of localized force in the midline, slightly headward of the umbilicus, using an over-and-under hand position in a way much more likely to achieve some degree of aortic contact compression. This technique has produced the most promising clinical results yet reported.<sup>1</sup>

The left-sided, angled technique proposed here for selective aortic compression may represent a further refinement. It is easy to teach, to remember, and to apply with minimal rescuer fatigue. Understanding of the location of the abdominal aorta and the shortest route to it from the skin surface are readily confirmed by self-examination or practice on a learning partner. The amount of force required to effectively compress the abdominal aorta with adventitial pressure approximating normal mean arterial pressure can be appreciated in normal individuals from the force required to maximize the aortic pulse palpable through the heel of the right hand in the IAC position of Fig. 2. In future clinical studies of IAC-CPR a more selective abdominal compression technique, which takes into account relevant human anatomy, may well produce better and more consistent results than those obtained heretofore.

Thanks to Willis .A. Tacker Jr. and Jack C. Debes for suggestion of the terms “contact compression” versus “hydrostatic compression”; to L.A. Geddes for recommending the use of a water-filled bladder for recording aortic pulsations; and to William E. Schoenlein for technical assistance.

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