An experimental study of the effects of puncture of the heart in cases of chloroform narcosis / by B.A. Watson.

Compliments of the Author.

AN EXPERIMENTAL STUDY

29

OF

THE EFFECTS OF PUNCTURE OF THE HEART

IN

CASES OF CHLOROFORM NARCOSIS.

BY

B. A. WATSON, A.M., M.D.,

SURGEON TO CHARITY, ST. FRANCIS, AND CHRIST HOSPITALS, JERSEY CITY, N. J.

REPRINTED FROM THE

TRANSACTIONS OF THE AMERICAN SURGICAL ASSOCIATION,

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THERE has been, already, considerable written on cardicentesis, although the operation was originally proposed and performed in 1882, by Dr. B. F. Westbrook, of Brooklyn, N. Y. Prior to this date several unintentional punctures of the heart had been made without being followed by unfavorable results.

Dr. John B. Roberts reported two cases of this kind at a stated meeting of the College of Physicians of Philadelphia, January 23, 1883.[1] He likewise called attention to the fact that[2] "Cloquet, Bouchut, Legros and Onimus have also observed the apparent innocuousness of wounds of the heart made with capillary trocars. Steiner found, ten years or more ago, that electro-puncture needles could be quite safely introduced into either ventricle, provided they were at once withdrawn."

Dr. F. M. Corwin reports in detail a case in which a puncture was made in the right ventricle, about one inch from its apex, without giving rise to any unfavorable symptoms.[3] Dr. C. L. Dana has reported two cases[4] in which punctures of the right ventricle were made with negative results. The reports in both these cases are so meagre as to diminish greatly the value which they would otherwise possess; but the comments on cardicentesis are unquestionably highly valuable.

[1] The Medical News, vol. 42, p. 45. [2] Ibid.
[3] The Mew York Medical Record, vol. 23, p. 263.
[4] Loc. cit., vol. 23, p. 140.

Having referred briefly to the literature of cardicentesis, which possesses an important bearing on our subject, although we believe this operation has never been performed on the human subject for the relief of chloroform narcosis, we will now briefly state the observation which prompted us to make these experiments.

While working in my laboratory, with my assistant, on the evening of February 20, 1887, I killed, with chloroform, a bulldog, which weighed forty-one pounds; and about four minutes after the cessation of respiration made an incision from the base of the neck in the median line to the symphysis pubis. This incision was promptly carried completely through the walls of the thorax and abdomen—thus exposing the heart, lungs, intestines, etc. The heart was observed to be entirely motionless and in full diastole, while the lungs were completely collapsed and lying in the posterior portion of the thoracic cavity, in close proximity to the vertebral column. My assistant, at this moment, seized the heart between his thumb and fingers, when the cardiac action was immediately resumed and the hand was removed.

The contractions promptly became full and regular, and during the first two minutes the pulsations were about sixty per minute, while during the succeeding minutes they became irregular and stopped at the end of this period, but only to be stimulated into action by the second touch—action continuing two minutes—and was the third time started up in the same manner, but this time continued to beat only one-half minute and could not again be roused into action.

The lungs during this whole period remained completely motionless and there were no other indications of life.

These observations suggested to me the possibility of arousing the heart into action, even after the entire cessation of its movements, by the introduction of a needle into this organ. The following record shows the result of our experiments:

Experiment I.—Mongrel, male, aged one year, weighed twenty-four pounds. Dog narcotized with chloroform. The puncture was made in the fifth intercostal space, one minute after the cessation of the heart's action. Three seconds after the needle penetrated the heart it

began to beat regularly at the rate of 120 per minute, which continued about twenty seconds and then became gradually slower and more feeble until it finally ceased pulsating, after one minute and a half. The puncture was made in the left ventricle about midway between the base and the apex.

EXPERIMENT II.—Mongrel, female, aged two years, weighed sixteen pounds. Dog narcotized with chloroform. The puncture was made with a medium sized aspirator needle in the fifth intercostal space, one minute after the cessation of the heart's action. The heart responded promptly to the puncture and continued to beat two minutes. The needle entered the septum ventriculorum midway between the base and the apex.

EXPERIMENT III.—Terrier, female, aged two years, weighed eleven pounds. Dog narcotized with chloroform. The puncture was made in the fourth intercostal space, one minute after the cessation of the heart's action. The heart began to pulsate after a few seconds, as was indicated by the movements of the needle. The pulsations finally ceased after one-half minute. The needle had penetrated the left ventricle near its base.

EXPERIMENT IV.—Scotch terrier, male, aged one year, weighed fifteen and three quarters pounds. Dog narcotized with chloroform. Puncture made one minute after the cessation of the heart's action. The needle entered the right ventricle near its base and very close to the septum ventriculorum. The aperture in the needle was occluded and there was no escape of blood through it. The response to the puncture was prompt, although the pulsations, at first, were very feeble, but they gradually became stronger. Two minutes and a half after the puncture was made, this dog began to breathe without having received any assistance. Respiration continued two minutes. The pulsations ceased seven minutes and a half after the puncture was made. The needle was allowed to remain in the heart until after the thorax was opened.

EXPERIMENT V.—Mongrel, male, aged two years, weighed twenty-seven pounds. Dog narcotized with chloroform. The puncture was made one minute after the cessation of the heart's action, in the fifth intercostal space to the right of the mesian line, with a small aspirator

needle, which entered the right ventricle. The responsive action of the heart was at first tardy and feeble, but became gradually strong and regular. After the lapse of two minutes the dog commenced a gasping respiration, which steadily improved until the animal fully recovered. No other efforts were made favorable to resuscitation except the puncture. The post-mortem examination revealed the presence of a very small quantity of blood within the pericardial sac.

EXPERIMENT VI.—Scotch terrior, female, aged three years, weighed fifteen pounds. Dog narcotized with chloroform, which was removed from the animal's nostrils immediately after the heart was punctured. The puncture was made with a small aspirator needle in the fifth intercostal space, a little to the left of the mesian line, one minute and a half after the cessation of the heart's action and a little more than a half minute after the stoppage of respiration. The needle entered the left ventricle. The responsive action of the heart was prompt and continued three minutes and a half. No additional efforts were made for resuscitation. The post-mortem examination revealed the presence of a small amount of blood within the pericardial sac.

EXPERIMENT VII.—Mongrel, male, aged eight months, weighed sixteen pounds. The puncture was made with a medium sized aspirator needle in the fifth intercostal space, a little to the left of the mesian line and entered the left ventricle about half an inch above the apex. The puncture was made one minute after the cessation of the heart's action, and half a minute after the stoppage of respiration. The heart promptly resumed its action, as shown by the movement of the needle. There was found a small quantity of blood within the pericardium.

EXPERIMENT VIII.—Terrier, male, aged five years, weighed eleven and a half pounds. Dog narcotized with chloroform. Respirations stopped about half a minute after the cessation of the heart's action. Two minutes after the stoppage of pulsations the heart was punctured, when it again resumed its functions. This resumption was, however, feeble and continued only fifteen seconds.

EXPERIMENT IX.—Mongrel, female, aged one year, weighed twelve and one-half pounds. Dog narcotized with chloroform. Heart punctured two minutes after the cessation of its action. The entrance of the needle into this organ was indicated, within a few seconds,

by its movements, which continued feebly two minutes and then ceased. There was no escape of blood through the needle. There was a slight effort made to assist in the restoration of this animal by keeping up artificial respiration. The post-mortem examination showed that the needle had entered the left ventricle near its base. The lungs were found to be extensively inflamed.

EXPERIMENT X.—Mongrel, male, aged one year, weighed twenty pounds. Dog narcotized by chloroform. Heart punctured with a medium-sized aspirator needle, which entered near the centre of the right auricle. This puncture was made one minute and a half after the cessation of the heart's action, and one minute after the stoppage of respiration. The pulsations of the heart then became strong and regular after a few seconds, and so continued about three minutes; but soon after the lapse of this period the movements of the needle indicated that it was beating tumultuously, which continued several seconds, when its action became very feeble and irregular. There had been no attempt at respiration at the end of this period. The chloroform had been removed as soon as the puncture was made. The tongue had been promptly drawn forward sufficiently to prevent its obstructing the entrance of air into the lungs. No other efforts were made for the resuscitation of the animal until the movements of the needle had become almost imperceptible, when artificial respiration was resorted to with the most beneficial results, the pulsations of the heart becoming gradually stronger and more regular. The artificial respiration having been continued two minutes, the dog was then in a condition to go on to a permanent recovery without further assistance. This dog fully recovered. Fifteen minutes had already been occupied in this experiment since the heart was first punctured. The chloroform was now reapplied and respiration ceased after one minute, but the heart continued to pulsate four minutes.

During the whole period the drug had been so employed as to prevent the inhalation of all atmospheric air. One minute after the cessation of the heart's action the chloroform was again removed and a renewed effort was made for the resuscitation of the animal—which only succeeded so far as to excite a very feeble cardiac pulsation. The second efforts made for the resuscitation were the same as those which have already been mentioned as being made in the first. The needle had been allowed to remain in the heart during the whole period of our experimentation.

EXPERIMENT XI.—Mongrel, female, aged one year, weighed forty-one pounds. The heart was punctured with a medium-sized aspirator needle, two minutes after the cessation of its action, and one minute and a half after the cessation of respiration. The heart responded promptly, but rather feebly, and continued to beat three minutes. There was no attempt made at respiration and no effort at restoration except the puncture. The needle entered the left ventricle.

EXPERIMENT XII.—Skye terrier, female, aged one year, weighed fifteen and one-half pounds. Dog narcotized with chloroform. The heart was punctured one minute and a half after the cessation of its action, and one minute after the stoppage of respiration. The heart resumed its pulsation about three seconds after it was punctured by the needle. It was feeble at first, but gradually became stronger. After a lapse of two minutes, the tongue having been drawn forward, the dog began to breathe; although there had been no assistance rendered other than what has already been mentioned. The dog continued to breathe about two minutes, while the heart pulsated for fully five minutes. The cavity of the right ventricle had been punctured and the escape of blood through the needle was more than an ounce.

EXPERIMENT XIII.—Mongrel, female, aged four years, weighed twenty-seven pounds. Dog narcotized with chloroform. The puncture was made through the fourth intercostal space one minute after the cessation of the heart's action, when, after the lapse of a few seconds, the heart responded very feebly and continued to pulsate only half a minute. The needle entered the right auricle.

EXPERIMENT XIV.—Mongrel, male, aged two years, weighed seventeen pounds. Dog narcotized with chloroform. The puncture was made in the fifth intercostal space one minute after the cessation of the heart's action. The pulsations of the heart became clearly perceptible within a few seconds. The heart was soon pulsating strongly and regularly, while every impulse forced out of the needle a jet of blood, which was allowed to continue about two minutes, and was then stopped by plugging the lumen of the needle. The animal had already lost fully an ounce and a half of blood. Prior to the arrest of the hemorrhage the dog had resumed breathing, although entirely unaided beyond the puncture. He steadily improved, and,

after the lapse of about twenty minutes, the needle was withdrawn, and the dog allowed to run about the laboratory one hour.

Second experiment on the same dog. This animal was again chloroformed, and one minute after the heart's action had ceased the needle was reintroduced through the fifth intercostal space. The heart responded to the puncture and was soon beating twice in a second. It continued to pulsate regularly two minutes, after which it became gradually weaker until it finally ceased. The right ventricle was punctured in both cases.

EXPERIMENT XV.—Mongrel, female, aged one year, weighed nine pounds. Dog narcotized with chloroform. The puncture was made two minutes after cessation of heart's action, and one minute and a half after respiration had stopped. The heart responded promptly to the irritation of the needle, and blood soon spurted from it with a *per saltum* motion. The chloroform had been removed as soon as the puncture was made, and the tongue was then drawn forward so as not to interfere with the entrance of air into the lungs. Artificial respiration was resorted to about one minute and a half after the puncture was made. The dog was promptly and fully resuscitated.

Second experiment on the same dog. Chloroform again administered while the needle remained in the heart. It was now plugged, and, consequently, there was no hemorrhage. The dog came rapidly under the influence of the drug; respiration soon ceased, but the heart's action continued seven minutes after the cessation of breathing. The second efforts at resuscitation began one minute after cessation of the heart's action. The dog was again resuscitated by the same measures which had already been successfully employed, and are fully described in the report of this case.

Third experiment on the same dog. In this experiment the same methods were employed in the administration of the chloroform and the after-treatment of the dog, except the omission of artificial respiration. The respiration quickly ceased after the administration of chloroform had commenced, but the heart's action continued some minutes. The quantity of blood lost during the first experiment was probably about two ounces. During the other experiments there was no flow through the needle. The needle had been allowed to remain continuously in the heart from the time it was first introduced until after the thorax was opened. It had penetrated the cavity of

the right ventricle and there were found within the pericardium a few drops of blood. The needle had remained in the heart more than an hour, and during a considerable portion of this time the dog had been struggling or otherwise disturbed by our efforts at artificial respiration.

Experiment XVI.—Mongrel, male, aged three years, weighed twenty-eight pounds. Dog narcotized with chloroform. The heart was punctured one and a quarter minutes after the cessation of its action, and half a minute after breathing had ceased. The heart responded promptly, and pulsated quite strongly. Artificial respiration was commenced one minute after the puncture was made, and continued five minutes. The needle was introduced into the fourth intercostal space, and punctured the septum between the right auricle and the ventricle of the same side. There was no escape of blood, and no unaided respiration. The heart's action ceased about three minutes after the puncture was made.

Experiment XVII.—Mongrel, female, aged six months, weighed thirteen pounds. Dog narcotized with chloroform. The puncture was made in the fifth intercostal space, one minute and twenty seconds after cessation of the heart's action, and half a minute after respirations ceased. The heart responded after the lapse of a few seconds, and continued to pulsate four minutes. The post-mortem showed that the needle had entered the right ventricle. No efforts were made for the resuscitation of the animal mentioned in this report.

Experiment XVIII.—Skye-terrier, female, aged one year, weighed fifteen and a half pounds. Dog narcotized with chloroform. The puncture was made in the fifth intercostal space, one and a half minutes after the cessation of the heart's action, the needle penetrating the right ventricle about one inch from the apex. The heart responded after the lapse of a few seconds, pulsated feebly but regularly for half a minute, and then ceased.

Experiment XIX.—Mongrel, male, aged one year, weighed twenty-four pounds. Dog narcotized with chloroform. In this case there was much difficulty in determining the exact time when the heart's action ceased. It seemed to cease about three minutes before the cessation of respiration. The puncture was made one minute after the stoppage of breathing, and the heart responded fairly well. Blood

flowed through the needle. Artificial respiration was resorted to, and after having been continued two minutes, the dog was able to breathe without assistance. He continued to respire fairly well three-quarters of a minute, after which the breathing became shallow and feeble, and the animal quickly died. Artificial respiration was quickly resorted to, but without perceptible benefit. The needle had entered the right ventricle. The post-mortem examination of the brain revealed a marked congestion along the line of the superior longitudinal fissure, with some ecchymotic spots in the superficial brain-substance.

EXPERIMENT XX.—Mongrel, male, aged seven months, weighed six pounds. Dog narcotized with chloroform. The puncture was made one minute and fifteen seconds after cessation of the heart's action, and thirty-five seconds after the animal had ceased to breathe. The heart responded to the puncture fairly well, although it continued to pulsate only two minutes. This animal showed no other signs of life after the puncture was made. The needle was introduced through the fourth intercostal space, and penetrated the right ventricle, but did not reach its cavity.

EXPERIMENT XXI.—Mongrel, male, aged eighteen months, weighed fifteen pounds. Dog narcotized with chloroform. The heart was punctured about three-quarters of a minute after cessation of its action. The needle had remained in this organ about two minutes before there was observed the slightest resumption of the heart's action. Its movements were then very feeble, although comparatively regular. About this time the animal made a few gasping respirations, and soon after these efforts the heart was observed to be beating tumultuously, and death speedily followed. Artificial respiration was continued about four minutes. The post-mortem examination showed that the needle had penetrated the right ventricle, but had not entered its cavity.

EXPERIMENT XXII.—Mongrel, male, aged four years, weighed fifteen pounds. Dog narcotized with chloroform. The puncture was made one minute after cessation of cardiac action, and forty-five seconds after the breathing had ceased. The needle passed through the fifth intercostal space, and entered the cavity of the right ventricle. The responsive action of the heart was prompt and favorable, and there

was a free flow of blood through the needle. Artificial respiration was kept up for five minutes. The heart pulsated six minutes after it was punctured.

EXPERIMENT XXIII.—Mongrel, female, aged two years, weighed twenty and a half pounds. Dog narcotized with chloroform. The puncture was made three and a half minutes after cessation of the heart's action, and thirty seconds after the animal had ceased to breathe. The heart responded promptly to the needle, and continued to beat fully six minutes. Artificial respiration was employed immediately after the puncture was made, and two and a half minutes later this dog was breathing without assistance. He continued to breathe thus for two minutes, when it was deemed proper to resume artificial respiration, although we failed to resuscitate the animal.

There had been a slight flow of blood through the needle, which had remained in the heart during all these observations, and when the thorax was opened it was found to have penetrated the right ventricle near its auriculo-ventricular septum. The lungs were found to contain numerous hemorrhagic infarctions and showed marked indications of inflammation. The abdominal cavity contained about three ounces of coagulated blood, which had been evidently poured out from a ruptured bloodvessel four days previous to this examination. Further examination revealed several deep lacerations of the liver.

EXPERIMENT XXIV.—Mongrel, male, aged one year, weighed twenty-two pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, and the needle entered the cavity of the right ventricle. The flow of blood through the needle amounted to about one ounce and a half. The needle was introduced into the heart about one minute and a half after cessation of its action and about one minute after the animal had stopped breathing. Artificial respiration was promptly resorted to and kept up for six minutes. The heart responded promptly to the entrance of the needle and continued to beat regularly about two minutes, when it ceased. The post-mortem examination revealed a moderate congestion of both kidneys, a small clot on the anterior portion of the medulla oblongata, and also congestion of the spinal cord in the lumbar region. The latter condition was associated with a separation of the last lumbar vertebra from the first sacral.

EXPERIMENT XXV.—Mongrel, female, aged five years, weighed twenty-one pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, and the needle penetrated the cavity of the right ventricle one minute and a half after cessation of the heart's action, and one minute after the animal had stopped breathing. The blood flowed freely through the needle. The heart responded promptly to the irritation—pulsations were feeble and continued only two minutes and a half. Artificial respiration was resorted to promptly after the puncture was made, and continued five minutes.

EXPERIMENT XXVI.—Mongrel, male, aged four years, weighed sixteen and one-half pounds. Dog narcotized with chloroform. The puncture was made two minutes after cessation of the heart's action, and one minute after the animal had ceased to breathe. The right ventricle was punctured by the needle and about one-fourth of an ounce of blood had escaped when the instrument was withdrawn. The heart responded fairly well to the needle, and its pulsations continued two minutes and a half. Artificial respiration was commenced two minutes after the puncture was made, and continued four minutes. The post-mortem examination revealed the fact that the lungs were studded with hemorrhagic infarctions. Some of the infarctions were larger than a pea, while others were no larger than the head of a pin. Two lobes of the lungs were completely consolidated. There was also a slight laceration of the liver.

EXPERIMENT XXVII.—Mongrel, male, aged one year, weighed thirteen pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, and penetrated the lower portion of the right ventricle one minute after cessation of the heart's action, and forty seconds after the animal had ceased to breathe.

The heart failed to respond for one minute, and then the needle was moved by my assistant, when the organ began to pulsate strongly, but its action gradually became more feeble, and finally ceased after the lapse of three minutes. Artificial respiration was not commenced until after the heart had resumed its action, but it was continued about four minutes.

EXPERIMENT XXVIII.—Mongrel, male, aged three years, weighed twenty-three pounds. Dog narcotized with chloroform. The heart was punctured one minute after cessation of both pulsation and res-

piration, these functions having ceased at the same time. The resumption of the heart's action was prompt but feeble, and continued only one minute. Artificial respiration was promptly employed, and continued a few minutes after death. It was found very difficult fully to narcotize this animal. It required more than three times the quantity of chloroform which we had been accustomed to use in similar cases. It likewise occupied us fully three times as long as the other cases. The needle entered the right ventricle near its base.

EXPERIMENT XXIX.—Mongrel, female, aged three years, weighed thirty-four pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, and the needle entered the right ventricle midway between the base and apex one minute and a half after cessation of the heart's action, and one-half minute after respiration had ceased. The responsive action of the heart was prompt, and it continued to pulsate about four minutes, but feebly toward the end of that period. Artificial respiration was soon commenced and continued five minutes. The post-mortem examination revealed a large hemorrhagic infarction in the right lung, marked congestion of both kidneys, ecchymotic condition of both the psoas muscles and the surrounding tissues, and a complete separation of the last lumbar vertebra from the first sacral, with rupture of the ligaments.

EXPERIMENT XXX.—Mongrel, female, aged one year, weighed twenty pounds. Dog narcotized with chloroform. The heart was punctured through the fifth intercostal space and penetrated to the cavity of the right ventricle midway between the base and apex. The needle was introduced into the heart one minute and three-fourths after the cessation of its action, and one-half minute after the animal had ceased to breathe. The heart did not respond promptly, although there was a free flow of blood through the needle. The needle was freely moved, but without causing the heart to pulsate. Artificial respiration was commenced and the heart began to beat strongly at long intervals, one minute after it was penetrated. Artificial respiration was kept up during this period, and continued several minutes after cessation of the heart's action. The post-mortem examination revealed a hemorrhagic infarction of the middle lobe of the right lung, which was surrounded by an inflamed and solidified ring nearly an inch in width. There was also a marked congestion of the left kidney.

EXPERIMENT XXXI—Mongrel, male, aged five years, weighed thirty-two pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, one and a half minutes after cessation of the heart's action, and half a minute after the animal had ceased to breathe. This puncture did not produce a responsive action in the heart, and the needle was partially withdrawn, since it was believed to have passed a little to the posterior of that organ, and was reintroduced, being now thrust backward and forward, and distinctly felt to enter the central organ of the circulation, but no pulsations followed. Artificial respiration was commenced about one minute after the heart was punctured, and it had been continued two minutes, when the animal suddenly gasped, and then made about six full inspirations. No pulsation of the heart occurred until after the animal made the first gasping inspiration, although three minutes had elapsed since the heart was punctured, but that organ now continued to pulsate feebly one minute. The final cessation of the heart's action was synchronous with the final stoppage of the breathing. The post-mortem examination revealed the fact that the final puncture had perforated the right ventricle midway between the base and apex, while in the first instance the needle had entered the upper portion of the inferior vena cava. The thoracic cavity contained about three ounces of blood which had escaped from the opening made by the first puncture. Both kidneys were markedly congested.

EXPERIMENT XXXII.—Mongrel, female, aged one year, weighed sixteen pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, and the needle entered the right ventricle near its base, one minute after cessation of the hear's action, and about twelve seconds after the animal had ceased to breathe. The heart did not respond for one minute, but then began to pulsate feebly, and continued so to act for one minute, when it finally ceased. In the meanwhile the artificial respiration, which was commenced immediately after the puncture was made, had been steadily kept up, and was continued for five minutes. The post-mortem examination revealed several large hemorrhagic infarctions in the lungs, which had given rise to considerable inflammation and consolidation.

EXPERIMENT XXXIII.—Mongrel, male, aged two years, weighed twenty-four pounds. Dog narcotized with chloroform. The puncture was made through the fourth intercostal space, and the needle entered

the right auricle close to its auriculo-ventricular septum, one minute and fifteen seconds after cessation of the heart's action, and half a minute after the animal had ceased to breathe. The heart responded to the puncture, and pulsated strongly and regularly one minute, when the needle was withdrawn, and consequently we are unable to state accurately how long the heart's action continued. Artificial respiration had been promptly commenced, and was continued for five minutes. The post-mortem examination revealed hemorrhagic infarctions in the lungs, with marked inflammatory action; a partial separation between the last lumbar vertebra and the first sacral, with inflammatory changes in the lower portion of the spinal cord, and likewise about an ounce and a half of blood in the thoracic cavity, and about one-fourth of an ounce in the pericardial sac. This escape of blood had evidently been from the puncture in the auricle.

EXPERIMENT XXXIV.—Mongrel, male, aged five years, weighed twenty-five pounds. Dog narcotized with chloroform. The puncture was made one and a half minutes after cessation of the heart's action, and half a minute after the animal had ceased to breathe. The needle had entered the right ventricle near its base. The heart responded promptly, but the duration of its action was not recorded. Artificial respiration was promptly commenced, and continued four minutes. The post-mortem examination revealed nothing which is regarded as important in connection with this report.

EXPERIMENT XXXV.—Mongrel, male, aged one year, weighed fourteen pounds. Dog narcotized with chloroform. The puncture was made in the fifth intercostal space, and the needle entered the right ventricle one minute after cessation of the heart's action, and forty seconds after the animal ceased to breathe. The heart soon commenced to pulsate. Artificial respiration was immediately employed, and when it had been kept up one minute the dog was breathing without assistance. This favorable condition continued three minutes, when it was again found necessary to resort to artificial respiration, which was continued six minutes. The heart pulsated eight minutes. Post-mortem examination revealed a large hemorrhagic infarction in the right lung, an extensive laceration of the liver, and a considerable quantity of extravasated blood within the peritoneal cavity.

EXPERIMENT XXXVI.—Mongrel, female, aged two years, weighed nine pounds. Dog narcotized with chloroform. The puncture was

made one minute after cessation of the heart's action, and forty-five seconds after the animal ceased to breathe. The heart responded very feebly to the puncture, and continued to pulsate about two minutes. Artificial respiration was promptly resorted to, and when it had been kept up a little more than one minute the dog began to gasp, and continued to breathe without assistance three-quarters of a minute. The post-mortem examination showed that the needle had punctured the inferior vena cava. The thoracic cavity contained about three ounces of blood, which had just escaped from the wound made in the vein.

EXPERIMENT XXXVII.—Mongrel, male, aged two years, weighed eighteen pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, and the needle entered the apex of the heart one minute after cessation of its action, and forty-five seconds after the animal had ceased to breathe. The heart responded promptly, pulsated regularly and strongly nearly six minutes, and only became feeble and irregular toward the end of this period. Artificial respiration was faithfully employed. The post-mortem examination revealed a partial separation of the last lumbar vertebra from the first sacral, which had resulted from a rupture of ligaments.

EXPERIMENT XXXVIII.—Mongrel, female, aged one year, weighed twenty-five pounds. Dog narcotized with chloroform. The puncture was made one minute and thirty-five seconds after cessation of the heart's action, and half a minute after the animal had ceased to breathe. The blood flowed freely through the needle, but the instrument remained entirely motionless. Artificial respiration was promptly employed, and the dog showed some signs of recovery when it had been continued a minute and a half; he then gasped a few times and died. The post-mortem examination revealed the fact that the needle had passed through the base of the right lung, entered the right auricular appendage, and passed through this into the auricular cavity.

EXPERIMENT XXXIX.—Terrier, female, aged one year, weighed eight pounds. Dog narcotized with chloroform. The puncture was made through the fifth intercostal space, and the needle entered the apex of the heart one minute after cessation of its action, and a half minute after the animal had ceased to breathe. The heart responded promptly, and continued to pulsate fairly well nearly three minutes. Artificial respiration was kept up about six minutes, but the

animal at one time during this period made a few gasping respirations. The post-mortem examination revealed small hemorrhagic infarctions in the left lung.

EXPERIMENT XL.—Mongrel, male, aged nine months, weighed twenty-one pounds. Dog narcotized with chloroform. The puncture was made one minute after cessation of the heart's action, and more than two minutes after the dog had ceased to breathe. The needle had been passed through the fifth intercostal space, and entered the right ventricle. The heart responded promptly—pulsations feeble and tardy—but it continued to act three minutes. Artificial respiration had been promptly employed, and was continued until after the death of the animal. Hemorrhagic infarctions were found in the lower lobe of the left lung, surrounded by inflammatory consolidation. There was, likewise, congestion of the meninges along the superior longitudinal sinus of the brain.

There have already been reported forty experiments on animals suffering from traumatic injuries, and we now append a report of twenty experiments on healthy, uninjured dogs.

EXPERIMENT XLI.—Black and tan, male, aged two years, weighed sixteen pounds. Dog narcotized with chloroform. The puncture was made two minutes after cessation of the heart's action, and one minute after the animal had ceased to breathe. The heart's pulsations promptly returned. Artificial respiration was immediately employed, and the animal was soon breathing without assistance. This favorable condition continued about two minutes, when the dog suddenly fell on his side, and respirations ceased. Efforts were again made for the resuscitation of this animal, but were unavailing. The post-mortem examination revealed the fact that the needle had entered the superior vena cava, in close proximity to the heart. There was a small quantity of blood found in the thoracic cavity, although none had escaped through the needle. It was thought that death, in this instance, was caused by an injury to the nerves, but the autopsy failed to demonstate it.

EXPERIMENT XLII.—Mongrel, female, aged one year, weighed ten pounds. Dog narcotized with chloroform. The puncture was made one minute after cessation of the heart's action, and one and a

half minutes after the animal had ceased to breathe. The heart responded promptly to the puncture, it pulsated strongly, and the animal was so far restored as to breathe without assistance. This favorable condition continued only three minutes, when the respirations suddenly ceased, and all further efforts for restoration were unavailing. The post-mortem examination showed that the auricle had been punctured, and that there had been some blood poured out into the pericardial sac—probably the quantity did not exceed five or six drops.

EXPERIMENT XLIII.—Mongrel, female, aged two years, weighed fourteen pounds. Dog narcotized with chloroform. The puncture was made one minute and thirty-seven seconds after cessation of the heart's action, and half a minute after the animal ceased to breathe. The heart responded satisfactorily, and the dog slowly recovered without assistance. It was intended when this puncture was made to enter the right ventricle instead of the right auricle, which had been made an objective point in the two preceding cases.

EXPERIMENT XLIV.—Esquimaux dog, female, aged two years, weighed sixteen pounds. Dog narcotized wtih chloroform. The puncture was made one minute after cessation of the heart's action, and a half minute after the animal had ceased to breathe. The heart responded promptly, and the dog commenced breathing within a few minutes without other assistance. The needle was withdrawn after the lapse of a few minutes, and, inasmuch as the animal had already, apparently, fully recovered, he was again narcotized with chloroform. The heart, in this instance, continued to pulsate three minutes after the animal had ceased to breathe. The second puncture was made one minute after cessation of the heart's action, and four minutes after cessation of respiration. The heart responded rather feebly to this puncture; its pulsations continued six minutes, but we failed to resuscitate the animal, although artificial respiration was thoroughly employed. The post-mortem examination showed that the right ventricle was penetrated in both instances.

EXPERIMENT XLV.—Mongrel, female, aged one year, weighed nine pounds. Dog narcotized with chloroform. The puncture was made fully three minutes after cessation of the heart's action, and one minute after the animal had ceased to breathe. There was observed during the administration of the chloroform, a marked spasm of the

diaphragm. The heart responded feebly, and continued to pulsate only one minute. Artificial respiration was employed, but without producing any marked beneficial results. The small aspirator needle was used in making the puncture. The post-mortem examination revealed the fact that the right ventricle had been penetrated.

Experiment XLVI.—Mongrel, female, aged one year, weighed eleven pounds. Dog narcotized with chloroform. The puncture was made one and a half minutes after cessation of the heart's action, and one minute and fifteen seconds after the animal ceased to breathe. The heart responded feebly, and continued to pulsate two minutes. Artificial respiration was unsuccessfully employed. The post-mortem examination showed that the right ventricle had been penetrated, and there were a few drops of blood found within the pericardial sac.

Experiment XLVII.—Terrier, male, aged two years, weighed thirteen pounds. Dog narcotized with chloroform. The puncture was made one minute after cessation of the heart's action, and half a minute after the animal had ceased to breathe. The heart responded promptly, and the dog began to respire without having received much assistance, at the end of two minutes. This animal fully recovered. The puncture was probably made in the right ventricle, since it was intended for this part of the organ.

Experiment XLVIII.—Mongrel, male, aged two years, weighed twenty-five pounds. Dog narcotized with chloroform. The puncture was made one and a half minutes after cessation of the heart's action, and one minute after the animal had ceased to breathe. The needle was kept in place two minutes, and then withdrawn. There had been no escape of blood through it. Artificial respiration was commenced soon after the puncture was made, and was kept up fifteen minutes. The post-mortem examination showed that the needle had penetrated the right ventricle. There were found a few drops of blood within the pericardial sac.

Experiment XLIX.—Terrier, male, aged six months, weighed eight pounds. Dog narcotized with chloroform. The puncture was made one minute and fifteen seconds after cessation of the heart's action, and one minute after the animal had ceased to breathe. The heart responded soon, and continued to pulsate three minutes. Artificial

respiration was promptly commenced, and continued ten minutes. There had been in the meanwhile escape of a few drops of blood from the instrument. The post-mortem examination showed that the right ventricle had been penetrated, and a small quantity of blood was found in the pericardial sac.

EXPERIMENT L.—Terrier, aged three years, weighed sixteen pounds. Dog narcotized with chloroform. The puncture was made one minute after cessation of the heart's action, and a quarter of a minute after the animal had ceased to breathe. The heart did not respond promptly to the needle, but commenced to pulsate feebly after a few seconds. Artificial respiration had been continued three minutes, when the dog began to show signs of returning animation, and finally fully recovered after the lapse of twenty minutes. It is presumed that the needle entered the right ventricle, since this part had been made the objective point.

EXPERIMENT LI.—Mongrel, female, aged two years, weighed ten pounds. Dog narcotized with chloroform. The puncture was made two minutes after cessation of the heart's action, and one minute and forty-five seconds after the animal had ceased to breathe. The heart responded rather feebly, and continued to pulsate feebly when the needle was withdrawn. Artificial respiration had been commenced about one minute prior to the withdrawal of the needle, and blood had been flowing through it quite freely. There had certainly been lost, in this manner, at least half an ounce of blood. The animal so far recovered as to breathe about three minutes without assistance. Artificial respiration was continued several minutes after the unaided respiration had ceased. The post-mortem examination revealed the fact that the needle had penetrated the superior vena cava just above the auricle, which I had intended to puncture. Four or five ounces of blood were found within the thoracic cavity.

EXPERIMENT LII.—Mongrel, female, aged nine months, weighed nine pounds. Dog narcotized with chloroform. Puncture was made three and a half minutes after cessation of the heart's action, and half a minute after the animal had ceased to breathe. The heart did not respond promptly, but one minute after the needle was inserted it pulsated regularly, and with considerable force, which continued until the needle was withdrawn. One minute later fully half an ounce of

blood escaped through the needle. The post-mortem examination showed that the needle had penetrated the heart in the centre of the right ventricle. There was not a trace of blood within the pericardial sac.

EXPERIMENT LIII.—Mongrel, female, aged two years, weighed twenty-five pounds. Dog narcotized with chloroform. The puncture was made two minutes after cessation of the heart's action, and half a minute after the animal had ceased to breathe. The heart resumed its action half a minute after the puncture was made. Two minutes later the dog was breathing rapidly without assistance, and continued thus to breathe about three minutes, although during the last minute of the period the respiration became less frequent and more shallow. Artificial respiration, which had been commenced immediately after the puncture was made, was discontinued three minutes, while the dog was breathing unaided, but was recommenced when this assistance was again demanded, but failed to produce the desired results. The post-mortem examination showed that the needle had penetrated near the centre of the right ventricle. Three or four drops of blood were found within the pericardial sac.

EXPERIMENT LIV.—Mongrel, female, aged six months, weighed thirteen pounds. Dog narcotized with chloroform. The puncture was made one minute and forty-five seconds after cessation of the heart's action, and forty-five seconds after the dog ceased to breathe. The heart responded to the needle half a minute after it was punctured. Some blood had flowed through this instrument—probably less than a drachm—when it was withdrawn. Artificial respiration had been commenced, and two minutes later the dog was breathing without assistance. The respiration was, at first, very shallow, but gradually improved, and the dog fully recovered. The puncture was intended to be made in the right ventricle.

EXPERIMENT LV.—Mongrel, female, aged three years, weighed twenty-five pounds. Dog narcotized with chloroform. The puncture was made four minutes after cessation of the heart's action, and one minute after the animal had ceased to breathe. The needle entirely failed to indicate any action of the heart until after independent respiration had been established, and even then its movements were very slight and feeble, which was fully three minutes after

the puncture had been made. Artificial respiration had been promptly employed, and continued two minutes before the dog showed any indication of returning animation. One minute later the animal was breathing without assistance, and continued thus to inspire about five minutes, when artificial aid was again resumed and kept up for two minutes, after which he breathed, unaided, seven minutes, and soon after died. The post-mortem examination revealed the fact that the needle had passed through the pericardium and entered the inferior vena cava, followed by a hemorrhage which had greatly distended this sac, and probably caused the death of the animal.

EXPERIMENT LVI.—Mongrel, male, aged six months, weighed ten pounds. Dog narcotized with chloroform. The puncture was made two minutes after cessation of the heart's action, and one minute after the animal had ceased to breathe. The heart responded feebly to the needle a half minute after it was introduced. The needle was promptly withdrawn before any attempt at artificial respiration was made. Two minutes after the commencement of artificial respiration the dog was breathing feebly without assistance. This favorable condition of things continued only about one minute and a half, when artificial respiration was again employed, but without success. It had been intended to puncture the right auricle. The post-mortem examination revealed the fact that the superior vena cava had been punctured. The pericardial sac was filled with blood.

EXPERIMENT LVII.—Mongrel, male, aged four months, weighed thirteen pounds. Dog narcotized with chloroform. The puncture was made two minutes and a half after cessation of the heart's action, and one minute after the animal had ceased to breathe. The heart responded *very feebly* to the needle. Artificial respiration was promptly resorted to and kept up while the needle was allowed to remain *in situ* fully three minutes before the animal showed the slightest indication of returning animation. The movements of the needle had gradually increased in strength and regularity. The needle was withdrawn as soon as the dog began to breathe without assistance. The breathing was very shallow at first, but gradually improved until complete recovery took place. Probably about a drachm of blood flowed through the needle. It is believed that the right ventricle was punctured, since this was the objective point in the case.

Experiment LVIII.—Mongrel, female, aged four months, weighed eight pounds. The puncture was made four minutes after cessation of the heart's action, and one minute after the animal had ceased to breathe. The introduction of the needle was followed by no responsive action. Artificial respiration was promptly commenced, and it was observed that every time the chest was compressed blood flowed freely from the needle, and when the loss of blood had amounted to about one drachm it was withdrawn. The needle was withdrawn ten seconds after the puncture was made, and is the only case in which no response was elicited where the cavity of the heart had been punctured. Artificial respiration was continued ten minutes. The post-mortem examination revealed the fact that the right ventricle had been punctured near its base. Not a trace of blood was found within the pericardium.

Experiment LIX.—Mongrel, female, aged three years, weighed twenty-three pounds. Dog narcotized with chloroform. The puncture was made three minutes and a half after cessation of the heart's action, and one minute after the animal ceased to breathe. The responsive action of the heart was prompt, but very feeble. The flow of blood through the needle was so profuse that it was withdrawn after the lapse of ten seconds. Artificial respiration was promptly commenced, and continued four minutes, until the dog was observed to gasp, from which time he gradually improved until he had fully recovered. The right ventricle was probably entered, since it was made the objective point of puncture.

Experiment LX.—Skye-terrier, male, aged four years, weighed twelve pounds. Dog narcotized with chloroform. The puncture was made two minutes and a half after cessation of the heart's action, and one minute after the animal had ceased to breathe. The heart responded very feebly, and this response lasted only a few seconds. There was no flow of blood through the needle. Artificial respiration was promptly employed, and continued ten minutes. The post-mortem examination showed that the needle had entered the right auricle. The pericardial sac was distended with blood, which had evidently come from the interior of the auricle.

Having completed the report of sixty experiments made on dogs, forty of which were animals suffering from complicating traumatic injuries, while twenty were perfectly healthy and

entirely uninjured, we will briefly present some of the results, and our conclusions drawn from this experimental study, with such explanations as will aid the reader in more fully comprehending these reports. There will be found incorporated in my report of these experiments, the post-mortem description of the gross lesions, and in all cases where this has been omitted, it has been because the examinations were entirely negative.

In the post-mortem examinations of the forty cases where we had a right to expect traumatic complications, they have been observed and described in fourteen cases. In the other twenty-six cases these examinations did not reveal any gross lesions. Commercial chloroform was employed in all our experiments. In the first fifty cases, which have been reported in the order in which they were performed, the chloroform was administered rapidly, and, so far as possible, atmospheric air was excluded from the animals, while in the last ten, the chloroform was administered slowly, and contained a large percentage of air. It is, therefore, evident, that in the first fifty cases the chloroform narcosis was accompanied by a certain degree of asphyxia. In the first eight experiments no other efforts were employed for the resuscitation of the narcotized animals than the puncture; while in the ninth case artificial respiration was resorted to, and afterward used more or less in all the cases, but employed with special care in the last twenty, which were the uninjured animals.

The cessation of the heart's action and of respiration as the result of the chloroform narcosis, has been noted in forty-seven of these experiments. In forty-four cases the heart's action ceased before respiration, but in the fortieth experiment the heart continued to pulsate one minute after respiration had ceased, and in the forty-second experiment the heart pulsated thirty seconds after the animal had ceased to breathe; while in the thirty-eighth the action of the heart and respiration ceased at the same time.

In thirty-four experiments, where the chloroform was administered rapidly, and without permitting atmospheric air to mix with the vapor of the drug during the inhalation, the

average continuation of respiration after cessation of the heart's action was nearly forty-one seconds, while the maximum in this class stands at two minutes, and the minimum is five seconds. There were, in this same class of experiments, ten cases in which the narcotized animal continued to breathe one minute or longer after the action of the heart had ceased, and only five cases in which the respiration continued less than thirty seconds after the heart had ceased to act. The ten experiments in which the chloroform was administered cautiously, atmospheric air being freely mixed with the vapor of the drug during its inhalation, give us a widely different result. In these ten cases there was not a single instance in which cessation of the heart's action occurred before the animal ceased to breathe.

The extremes are recorded in the report of Experiments LV. and LI. In the former experiment the heart's action ceased eight minutes before the animal ceased to breathe, while in the latter case the animal breathed only forty-five seconds after the heart's action was arrested. The average duration of respiration after cessation of the heart's action in these ten cases was two minutes and twelve seconds. The punctures made in the sixty experiments were as follows: In the right ventricle, 38; left ventricle, 6; right auricle, 6; the superior vena cava, 3; inferior vena cava, 2; apex of the heart, 2; not stated, 1. The resuscitations which followed these punctures were as follows: right ventricle, 9; right auricle, 1. The first forty experiments gave us only four recoveries, while the last twenty yielded six. The question will naturally be asked, Why this disparity? It should be remembered, in this connection, that the dogs experimented on in the first series were suffering more or less from traumatism, and consequently possessed less recuperative power than the twenty animals used in the second series, which were perfectly healthy, and entirely uninjured. Furthermore, the first series of experiments was made especially for the purpose of determining the effects of cardiacentesis in cases of chloroform narcosis, while the second series was intended to demonstrate its efficiency when em-

ployed in the treatment of these cases in connection with artificial respiration. Consequently, there was no resort, in the first eight experiments of the first series, to artificial respiration, or any other means of resuscitating these animals, and it is likewise true that in making the other thirty-two experiments of this series, we were chiefly intent on observing merely the effect of the punctures, and consequently did not make any systematic effort at resuscitation.

The most important question which presents itself here for our consideration is, What are the effects of a puncture of the heart in cases of chloroform narcosis? Let us now carefully examine the record of these experiments and determine their bearing upon this query. We find that there were sixty cardiac punctures, and that the heart only failed to respond in Experiments XXXVIII. and LVIII. A reference to the report of these cases shows that in the former instance the puncture was made one minute and thirty-five seconds after cessation of the heart's action, and one minute after the animal had ceased to breathe, while the post-mortem examination revealed the fact that the needle had passed through the base of the right lung, entered the right auricular appendage, and passed through this into the auricular cavity. This needle had failed to indicate any responsive action merely because it was so firmly held by the tissues through which it passed as not to be swayed by the feeble pulsations of the heart. In the latter case our report shows that the puncture was made four minutes after cessation of heart action, and one minute after the animal had ceased to breathe. In this instance the needle was entirely free to move, and it is, therefore, evident that it entirely failed to excite any responsive action in the heart, probably because of the loss of its vital power. A further examination of these reports shows that the needle puncture, unaided by any other means, was sufficient to arouse the heart into action in twenty-two of these experiments, while the average time which elapsed between cessation of heart action and the introduction of the instrument was one minute and twenty seconds; the longest period being two minutes, and the

shortest, one. The cardiac action thus excited continued in two cases; the other functions were promptly reëstablished, and the animals fairly recovered.

The real point of interest now centres in this question—Can the heart which has ceased to pulsate be goaded into action by needle puncture? If it be admitted that in these twenty-two experiments the heart had absolutely ceased to perform its functions, but was aroused into action by the needle puncture, then the affirmative is proven. Should it, however, be charged that the experimenter has failed to demonstrate cessation of the heart's action prior to the introduction of the needle, then the value of these experiments would be seriously questioned. Consequently, we will introduce other evidence, in order that the value of these experiments may be made more apparent. It will not be denied that the swaying movements communicated to the needle by the pulsations of the heart, when it has been introduced into that organ, should be accepted as positive proof of its action. The needle in this position transmits every movement of the heart as accurately as it is done by the writing lever of the sphygmograph. Consequently the operator, who watches these movements, is enabled to comprehend the peculiarities of the same.

An examination of the reports of the experiments shows that in thirty-two cases the heart did not promptly respond to the introduction of the needle, but its action was delayed in some instances as long as three minutes, and in other cases only a few seconds.

The following extracts from the report of these experiments are here introduced for the purpose of illustrating the subject under consideration. The heart was punctured in Experiment XXI. about three-fourths of a minute after cessation of its action. The needle had remained in the organ two minutes before there was observed the slightest resumption of its action.

In Experiment LIV. the puncture was made one minute and forty-five seconds after cessation of the heart's action, and forty-five seconds after the animal had ceased to breathe. The heart responded to the needle half a minute after the puncture was

made. Artificial respiration was then commenced and two minutes later the dog was breathing without assistance. The respirations were, at first, very shallow, but gradually improved and the dog fully recovered.

The last report conclusively shows that there had been a cessation of the heart's action, and that its resumption occurred without the use of any other means than the introduction of the needle. Additional evidence of this character is found in abundance in the reports of these experiments, but it is not considered necessary to proceed any further in this direction.

Attention is now called to the fact that in nearly all our experiments with chloroform, we have observed that cessation of the heart's action commonly occurs prior to the stoppage of breathing; but when the needle has been previously introduced into this organ the order is reversed. In support of this, the reader's attention is now directed to the following extract from the report of the tenth experiment: "The chloroform was reapplied and respiration ceased after one minute, but the heart still continued to pulsate four minutes. . . . The needle had been allowed to remain in the heart during the whole period of our experimentation.

Having already supplied the essential facts found in the record of our experiments, bearing on cardiacentesis in chloroform narcosis, the question may now be properly asked, Should the puncture be carried into a cavity of the heart in order that blood may be abstracted? The physiological condition of the heart and lungs in chloroform narcosis is well understood by the medical profession. The heart is always found in diastole and the veins in the lungs greatly distended with blood. I have made nearly one hundred and sixty post-mortem examinations of dogs killed with chloroform, and have universally observed these conditions, except in those cases where there had been a very free escape of blood just prior to the death of the animal. It may, therefore, be rationally claimed that blood may be advantageously drawn from the right side of the heart in cases of chloroform narcosis. I am, likewise, fully assured that this procedure is not only theoretically correct, but also entirely prac-

tical and highly advantageous. Let me ask, what more rational treatment can be adopted in cases of chloroform narcosis than the puncture of the heart and the abstraction of blood. In those cases where there is already complete cessation of heart action and respiration, what are the indications for treatment? The urgent indications are to restore promptly these important suspended functions. It may, however, be urged against this operative procedure, that it is not entirely free from danger; but the same argument may be urged with equal force against many operations. Furthermore, the desperate condition of a patient suffering from chloroform narcosis may justify a resort to measures which otherwise should not be employed.

The only deaths observed during my experimentation, which may be fairly charged to the puncture, are those in which the vena cava was penetrated. In these cases, a profuse hemorrhage into the thoracic cavity unquestionably influenced the fatal termination. The punctures made into the auricle were, in some cases, followed by the flow of considerable blood into the pericardial sac, and are not entirely free from danger. The punctures made into the ventricles are not attended by any hemorrhage from the interior of the organ, but there are occasionally found a few drops of blood within the pericardial sac, which has been poured out from some wounded cardiac vein.

The experimental study of cardiacentesis in cases of chloroform narcosis has enabled me to reach the following conclusions:

Firstly. Puncture of the heart, especially the right ventricle, stimulates muscular contractions and may be advantageously employed in the treatment of this morbid condition.

Secondly. The best results are obtained when abstraction of blood from the cavity of the ventricle is combined with the stimulating effects produced by the entrance of the aspirator needle.

Thirdly. Puncture of the right ventricle is a safer and more efficient operative procedure than puncture of the right auricle.

DISCUSSION.

DR. N. P. DANDRIDGE, of Cincinnati.

I feel much embarrassed in offering any remarks upon this paper, which is based upon so many experiments. The conclusions have been carefully drawn. The interest of such experiments depends upon the practical deductions which can be drawn as to the application of the procedure to the human being. Here, I think, we should be exceedingly careful in applying the deductions from experiments to practical purposes. The conditions under which the experiments were performed, and the conditions under which accidents occur in the human being are so exceedingly different, that deductions from the one are to be very carefully applied to the other. In these experiments, the anæsthetic was pushed to a dangerous limit, and in many cases overwhelming doses were given at once. In all cases it was given until dangerous symptoms manifested themselves. The accidents which occur from chloroform happen very frequently, probably in the majority of cases where only a small quantity has been given, and very often soon after the administration has commenced, the accidents, probably, being due to a reflex action upon the inhibitory apparatus of the heart. In the experiments reported there seemed to be a want of explicitness in regard to the time after cessation of the heart's action, that it could be aroused by the punctures. In most cases the puncture was made within one minute, or a shorter time. In accidents with chloroform it is not uncommon to have recovery take place after apparent cessation of the heart's action for a long time. I think that the experiments would have been of more value if they had been directed to an elucidation of this question of the period during which the heart could be aroused to action—whether or not, at the end of five or ten minutes, cardiac puncture would have the effect of re-establishing the heart's action.

In the paper of Dr. Senn, on air embolism, a few years ago, he found that in animals where there was impending death from the injection of air into a vein, a certain number of these animals might be saved by direct aspiration of the right auricle, provided it was done rapidly, and provided that the quantity of air was not excessive. He found that three animals out of ten were relieved in this way. His

object was to relieve the distention of the auricle, and thus relieve the paralyzed condition of its walls. The object was not, as I understand it, to stimulate the heart by traumatism, but was actually to draw off sufficient of the contents of the heart to allow the auricle to contract. This seems to have been only in part the object of Dr. Watson, who, in the majority of cases, relied on the stimulating effect of the puncture of the heart muscles themselves.

In regard to the conclusion which he draws, as to the relative efficiency of the puncture of the right ventricle instead of the right auricle, I have nothing to say. I should presume, *a priori*, that it was easier to puncture the right auricle, and also safer.

This subject is to me of especial interest, as I have lost one case by chloroform, and one by ether. Any light upon this subject which will enable us to manage these cases more satisfactorily is very desirable. It seems to me that in the practical deductions to be made from these experiments, we should be exceedingly careful in applying them to man, particularly where it involves such a grave procedure as puncture of the heart. A large number of experiments would be necessary to test the value of this procedure as compared with artificial respiration, the use of nitrite of amyl, and particularly the subcutaneous injection of atropia. The latter can always be done readily and quickly, and its effect on the cardiac and respiratory centres is well established. The preliminary injection of atropia and morphia a short time before the use of the anæsthetic in a grave operation, particularly where the patient is suffering from shock, has a decided preventive influence against sudden heart failure.

Dr. John B. Roberts, of Philadelphhia.

The paper of Dr. Watson has been instructive on at least two points—one intentional, and the other, perhaps, unintentional, although none the less so on that account. He shows the comparative innocuousness of puncturing the heart with a small needle, particularly if some point like the ventricle is selected. He shows indirectly the great danger of giving chloroform as an anæsthetic in any case, possibly cases of parturition excepted. I doubt if he could have killed so many dogs with ether.

His experiments prove very positively that there is more danger in puncturing the auricle than in puncturing the ventricle. This would naturally be suggested by the fact that the ventricle has a much

thicker wall than the auricle. Where the needle is left in the heart the persistent motion of the organ will probably have a tendency to lacerate the thin wall of the auricle, which, moreover, would be less likely to prevent extravasation than would the thick wall of the ventricle.

The point raised by Dr. Dandridge, that in these experiments a great deal of chloroform was given, while in the human race only a small quantity is employed, does not seem to me to be against the operation, for if it does well where a large quantity of chloroform has been given, it should do better on a human subject where a small quantity has been given, provided that man and the dog are equally suited to the same operative procedure.

The paper of Dr. Senn, read a year or two ago, is *apropos* as enforcing the lesson that puncture of the heart done by a proper method is not a serious operation. The use of narcotics and atropia in ether and chloroform narcosis is valuable, but atropia is rather slow in its action on the heart, if it is a heart tonic, although probably not so slow as digitalis.

In my paper[1] referred to by Dr. Watson, I speak of the experiments of Dr. Westbrook, who punctured the heart for other conditions than chloroform narcosis, his idea being that by drawing blood from the right side, he might relieve the distended heart. I have, apparently, saved life by phlebotomy in cases of great engorgement of the lungs in acute pneumonia; and have seen relief follow in cases of damaged heart, from the same procedure. Dr. Westbrook, of New York, and Dr. Leuf, formerly of Brooklyn, but now of Philadelphia, have reported cases in which heart puncture was performed on the human subject.

I was gratified to hear Dr. Watson say that puncture of the right ventricle was safer than puncture of the right auricle. Dr. Westbrook believes that the proper place to perform the operation is in the third interspace close to the right edge of the sternum, which enables him to tap the auricle. I suggested that it would be better to perforate the ventricle of the right heart by introducing the needle through the fourth interspaces, about one and a half or two inches to the left of the median line of the sternum.

Another point suggested by the paper is with reference to the possibility of other operations on the heart. Dr. Block claims that he

[1] Transactions of the College of Physicians of Philadelphia, Jan. 3, 1883.

has been able to suture the hearts of rabbits, and that it is a simple operation, requiring but three or four minutes. He finds that opening of the right and left ventricle and entire compression of the heart for the application of sutures can be supported by rabbits for several minutes. Even if cardiac pulsation and respiration stop during this mechanical interference with the heart's movement, death, he asserts, does not necessarily ensue. I do not know Dr. Block, and believe that we should be careful in accepting such statements, though such operations do not seem impossible. In my paper above referred to I have given the references to his published account.

Dr. L. McLane Tiffany, of Baltimore.

There are two points in which I think that the experiments are open to marked criticism. The first is, that it is well known that under chloroform the dog behaves in a peculiar manner, so that for experimental dog work, chloroform is useless. The dog is very apt to die suddenly. Chloroform is banished from laboratories where dogs are required. It is, therefore, not proper to make any deduction from the dog to the human subject, the dog being under the influence of chloroform.

The other point is in regard to the conclusions which were adduced by experiment, that it was advantageous to puncture the heart in chloroform narcosis. If this is to be applied to man, I think that it merits criticism. To do an experiment in the laboratory, and advise others to do it in hospital and private practice, is not right. Experimental work in the laboratory is good, but it must be supplemented by practical human experience on the part of the experimenter before it is to be recommended for use to others.

Dr. R. A. Kinloch, of Charleston, S. C.

About two months ago, I had a case of chloroform narcosis in which heart puncture was tried. While I have been accustomed to use the A.-C.-E. mixture, my assistant prefers chloroform. While I was preparing for the operation my assistant put the patient under the influence of chloroform. After a time, we both noticed something wrong with the patient, and I was convinced that he was about to die. I resorted to the usual measures without avail. Dr. Edwards suggested heart puncture, and I told him he was at liberty to try it. He endeavored to puncture the right ventricle, without effect. I then took the needle

and introduced it myself. No effect was observed. There was no movement and no flow of blood from the needle, which was that of a hypodermic syringe.

DR. T. J. DUNOTT, of Harrisburg, Pa.

I should like to relate the history of a case in which the heart was twice punctured with an aspirator trocar without immediately fatal results. The patient resided in Williamsport, and the history was given to me by Dr. Thomas Helsby, who was present at the post-mortem examination, in 1877. The patient, from early life, had suffered from mitral insufficiency, and when operated on had a greatly dilated heart, and was suffering from orthopnœa, great pulmonary congestion, and general anasarca. She was at the time under the care of two homœopathic physicians. They regarded the case as one of pericarditis, with effusion, and attempted to aspirate the pericardium with the result of penetrating the ventricle and removing with the aspirator ten to fifteen ounces of blood, which rapidly coagulated. They did not recognize at the time that they had penetrated the heart. The urgent symptoms were relieved temporarily, and, in consequence, they made a second attempt after some days' interval, but the patient died in a short time. At the post-mortem the marks of the punctures were distinctly perceptible.

DR. WATSON. Dr. Dandridge has objected to the fact that I did not specifically call attention to the period of time which might elapse after the heart had ceased to act, when it was possible to arouse it into action by puncture. A careful reading of the paper will show that I succeeded a number of times in exciting the heart's action even three minutes after it had ceased. In one instance I introduced the needle four minutes after the cessation of the pulsation, but failed to get any response. It would, of course, be impossible to elicit a response even from puncture after the lapse of a certain time. It is quite certain that there is a slight irritability which remains a certain period after the cessation of both the heart's action and respiration. To determine this period exactly would probably require innumerable experiments.

In regard to puncture of the right ventricle instead of the right auricle, I would state that there are two reasons for this recommendation. In the first place, the wall of the right auricle is much thinner, and contains less muscular tissue than the wall of the right ventricle.

The auricle is, in every respect, a sort of reservoir for the blood. The propelling power, to a great extent, belongs to the strong muscular walls of the ventricle. There is another reason why we should not puncture the right auricle, for, as the wall of the auricle is thin, there is more danger of blood escaping. The needle left in the wall of the ventricle has not produced laceration, neither does it produce laceration when left in the thin wall of the auricle. I think that when the auricle is punctured there will always be a certain amount of leakage. In no case of puncture of the right ventricle was there any leakage from the interior of the cavity. There is, however, risk of puncture of the cardiac veins, with the occurrence of hemorrhage, which is comparatively trifling.

In regard to the difference of action of chloroform upon man, and upon the dog, I may state that I am familiar with all that Dr. Tiffany has said. The difference is, however, in favor of the man and not in favor of the dog. Chloroform cannot be continued safely with the dog for any length of time. In some experiments reported to this Association some years ago, I showed that when I attempted to continue the anæsthetic action of chloroform on dogs for two hours I lost half of the animals. The same physiological conditions pertain to the dog as to man, when you use chloroform, and the same pathological conditions are found in the dog as when it is given to man. When an animal is destroyed with chloroform it is found that the heart is in diastole, and that the veins of the lungs are engorged. This is the universal result, unless profuse hemorrhage has taken place. The first object is to irritate the heart and cause contraction. I think if the paper is read, it will be found that puncture does irritate the heart, and cause contraction. Muscular contraction may take place, but if the heart is still distended with blood, and if the heart does not contract sufficiently to force out this column of blood, what is the result? Therefore, I believe that, in addition to puncture, we should enter the cavity of the ventricle and draw off some blood. My experiments show conclusively the advantage of this. The cases in which I succeeded in drawing off blood did better than those in which no blood was drawn.

Atropia may be good, but I may say that, as a heart elevator, I should rather have a needle in the heart, and I should have more confidence in this than in the administration of atropia. In none of my experiments did I puncture within a period less than one minute, and, in some instances, three minutes elapsed. The rapid administration of

chloroform does not produce the best condition for the resuscitation of the animal. One man in this country believes that it should be forced on the patient, and he always administers it in that way. My experiments show that when I gave it rapidly the heart's action continued a little longer than the respiration in two instances, but when I gave it cautiously, which I did in the last ten experiments, I found that in every instance its action was much more uniform, and that it did not kill the animal so unexpectedly. When chloroform had been given cautiously, I found that it was possible to resuscitate the animal after a longer period. The heart ceased to beat, but the animal continued to breathe. In one instance the animal breathed for eight minutes after cessation of the heart's action. I could arouse the animal two or three minutes after the heart had ceased to beat when the agent had been given cautiously, but in those cases in which it had been forced, it was with great difficulty that the heart's action was aroused. I would argue, therefore, that it was better to give it cautiously, and with an abundance of atmospheric air.

In the first forty cases, my object was to kill the animal, so as to make a post-mortem, and determine the lesions present. In the last twenty healthy animals, I resuscitated six, and when they recovered from the puncture they continued to live, and are still living.