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THE PRESENT STATUS OF ROENTGEN THERAPY IN THE FIELD OF CANCER—ITS PAST HISTORY AND ITS FUTURE*

FLOYD J. TRENERY

The history of radiation therapy is indeed fascinating. Its entire development has occurred during the lifetime of most of us present here today. Its growth has been spectacular. Much of its true progress and advancement has been based, not upon medical science, but upon physics, engineering and biology. The purely scientific background from the standpoint of physics was fairly well established before the epoch making announcement of the discovery of the x-ray by Wilhelm Konrad Roentgen on November 8, 1895. Roentgen was one of a large number of scientists of the time who were actively engaged in the investigations of the cathode rays, fluorescence, electrical phenomena and allied subjects. The atomic theory was widely accepted. The Bohr atom had been described. Ionization was fairly well understood. The fundamental laws of radiation as applied to infra-red, visible light, and ultraviolet were common knowledge. Electrical engineering was an established science. Roentgen's discovery was the final step in a brilliant and logical correlation of a multitude of facts which had been disclosed by many scientists. It was not until December 28, 1895, that Roentgen made his official report to the President of the Wurzburg Physical Society, and then waited until January 23, 1896, before speaking publicly on the subject of his discovery. The amazing news had spread with unbelievable rapidity by means of the press to every part of the world. Physicists in universities and colleges all over the world quickly duplicated Roentgen's experiments with Crooke's tubes both with fluorescent screens and with photographic plates and sensational reports were published even before Roentgen's own preliminary report was published. The medical journals of the day were quick to pick it up. German medical journals published accounts on January 14 and 16, 1896. The Lancet and the British Medical Journal published articles on "Searchlight Photography" on January 11, 1896, the French on January 20, 1896, the Italians on January 25, 1896, and in America the Medical Record published an article "Illuminated Tissues" on January 11, 1896, and the Journal of the A. M. A. published an article "A New Kind of Rays" on February 15, 1896.

Throughout the year there was feverish activity all over the scientific world. Most of the work was radiographic and radioscopic, and many of the fundamental principles of roentgen diagnosis were quickly established. During the year thousands of articles and some fifty books were published,
and before the end of 1896, the sad and frightful results of over exposure of human tissues began to appear and with them the beginning of x-ray therapy. The effects upon the skin were not understood and at first were blamed upon many causes other than x-rays which were thought by most to be only beneficial. Feeling confident that the x-rays were harmless they explained the skin reactions to be due to ozone and nitrous oxide generated by the apparatus; bacteria driven into the skin; cathode rays driven into the skin; electrical fields; heat rays; ultraviolet rays from the tube, etc. Among the first to recognize and warn of the harmful effect of x-rays was Elihu Thomson of Boston who mentioned this subject in an article in the publication "Electrical Engineering" in March, 1896. Rollins in the "Electrical Review" in January 1896, suggested that vacuum tubes could produce burns. Kienböck in Germany reported in 1900 on experiments with rats which proved the biological effect of x-rays. All through the year of 1896 the medical literature of both America and Europe contained various articles concerning dermatitis in connection with the use of x-rays. The earliest observations proved correct. It appears that the manufacturers of electrical equipment of the time had spread the word of the harmlessness of the rays. However, by the end of 1897, there were several reports of studies of cases of x-ray injury. In January 1897, Kibbee of Seattle, Washington, reported on the results of microscopic examinations of skin injured by x-rays. Other observers noted the epilating effect of x-rays. The early literature contains several interesting reports on this subject. Dr. Leopold Freund of Vienna was probably the first to report, in March 1897, the use of x-rays for their therapeutic effect alone. He treated a young girl affected with a disfiguring hairy nevus. The lesion was large, extending from the neck down over the posterior thorax. He described the technique as follows: "A 20 cm. coil, 10 cm. tube skin distance, the intensity sufficient to photograph the hand in 60 seconds. The area was treated in one single field, 2 hours each day to a total of forty-two hours of radiation. Epilation began on the seventh day. Later extensive ulceration developed which required several excisions. Five years later a lesion the size of a guilder remained." Immediately following this report there was tremendous activity in roentgen therapy. At first only superficial conditions were treated, such as lupus, lupus erythematosus, psoriasis, sycoisis and favus, nevus vasculosus, chronic eczema, epithelioma, superficial sarcoma, mycosis fungoides, and by 1903 Pusey and Senn reported the treatment of leukemia and lymphadenoma. Soon the treatment was applied empirically to every known disease. Although European physicians were first to use x-rays for therapeutic purposes, their work was quickly followed by Williams of Boston and Leonard of Philadelphia. Williams published a book in 1901 in which he refers to the "cumulative action of x-rays" and recommends protection of the patient by shielding the tube and the patient with lead. As an addendum to the second edition of his book in 1902 he states, "I am now pursuing further this general question of the use of x-rays as a therapeutic agent in diseases involving glands, including the prostate gland."
The dosage used in the beginning was far from uniform. Even the most careful and experienced operator found it almost impossible to duplicate results. The first x-ray tubes were Crooke's tubes picked up in physics laboratories and from electrical supply houses. The generators were coils and static machines, most of them already owned by electro-therapists. Soon various types of x-ray tubes appeared on the market.

In 1907, Clyde Snook of Philadelphia produced a step-up transformer with its cross arm rectifying switch. Snook's first transformer is in Baltimore and was in regular use until just a few years ago. The last Snook transformer shipped from Clyde Snook's factory was sold to S. L. Taylor and the writer in 1916 and is still in daily use in Byron L. Cash's laboratory at the Des Moines General Hospital.

It was 1913 before Dr. Coolidge produced his hot cathode and provided a tube with stable characteristics whose output could be duplicated if the factors applied to the tube were the same.

Measurement of high voltage currents was by means of the spark gap until 1921 when the sphere gap was perfected by a committee of physicists and engineers in conjunction with the American Society of Electrical Engineers.

The almost universal method of calculating dosage finally included KvP, Ma, filter, distance, time, and field size. This method followed various others, beginning as early as 1897 by that of Dorn in which he attempted to calculate the actual energy transported by the beam by measuring with an air thermometer the heat produced by absorption of the radiation by sheets of metal. In 1900 Rutherford and McLung attempted to measure the energy of radiation by means of a bolometer. The actual amount of heat was so small that accurate measurements proved impractical. Next followed a number of photo and photochemical methods. The luminous methods of Guilleminot and of Wintz and Rump, proved inaccurate because of inability to read accurately the visual photometer. The Holzknecht and the Sabouraud-Noire methods proved inaccurate chiefly because it was found that both the platinum and the barium in the pastilles have discontinuities of absorption in the region of the wave lengths then used in therapy, as well as being sensitive to heat and to visible light. Kienböck attempted to use silver bromide paper as an indicator but inaccuracies in developing technique made this impractical. Other less known chemical methods were tried and discarded for various reasons. Then came the selenium cell which was finally discarded because of inaccuracies. It was found that its maximum sensitivity was at a wave length of about 0.25 Å and this type of radiation has little or no use in therapy. No universally accurate method of measuring intensity was found until the adoption of the roentgen in 1928 at the Second International Congress of Radiology in Stockholm and revised at the Fifth International Congress of Radiology in Chicago in 1937. During that long stretch of years up until 1928, the most careful operators recorded KvP—Ma—distance—time—filter and field size. Milliampere seconds, Milliampere
minutes and Milliampere hours were commonly used terms. Hundreds of casual workers gave “shots” of x-ray or “series of exposures” with no idea whatever of how much or of the quality of radiation given. Text books, especially on the skin diseases, frequently closed a paragraph on the treatment of a disease by saying, “X-rays are said to be beneficial.”

The ionizing effect of the roentgen ray has long been known. Roentgen himself described it in his preliminary report in December 1895. Thomson described its effect in 1896. In 1908 Villard suggested its application to dosage measurement and defined the unit of quantity as “that which liberates by ionization one e.s.u. of electricity per cc. of air under normal conditions of pressure and temperature.” Though his unit was almost the same as the roentgen, it apparently went over the heads of the therapists and it was never used. Duane of Harvard in 1905 recognized wall effect in an ionization chamber. Kronig and Friedrich in 1918 revived Villard’s suggestion, and Soloman in 1921 proposed a unit called r based on the constancy of the gamma ray through 0.5 mm. of Pb. Behnken in 1924 defined the roentgen which was adopted in Germany. Blasser and Meyer used instruments imported from Germany in 1926. Duane in 1927 proved that his unit was within 0.7% of the German unit. Since 1928 all radiologists have accepted the specifications for the international roentgen and we now have a fairly accurate and uniform unit of quantity of radiation.

**Filtration**

The early roentgen therapists used no filtration. As late as 1915 Tousey mentions casually that a screen for soft rays may be used. It was recognized that the quality of radiation was dependent upon the voltage applied to the tubes. With the old gas tubes, the degree of vacuum usually limited the voltage capacity of the tube. Potts of the University of Pennsylvania in 1911 does not mention filters but recognized the varying qualities of x-rays. However, Kassabian in his text published in 1907 tells of experiments conducted by Pfahler and Schamber upon rabbits in which the use was made of silver, leather and aluminum for the purpose of establishing their value as filters. They found that “Leather filtered out the soft, medium and hard rays.” They were impressed with the fact that the susceptibility to the rays varied in different animals which doubtless is also true of man. Pfahler was probably the first (1906) to recommend the use of “heavy filtration,” 3.0 mm. al. and a thickness of sole leather, and to observe what has been accepted as the erythema dose and its recovery period which permitted the dose to be repeated. Van Zwollenberg of Ann Arbor and Russell Boggs of Pittsburgh were prominent among the therapists of the second decade who recommended “Heavy filtration.”

After the World War I, a new advance was announced. The Germans, Wintz and Seitz, were using machines which were said to operate at a 20” spark gap. The most powerful American machines operated at
an 11" spark gap. The German machines were said to have a KvP of 200 as compared to 110 to 140 KvP of the American machines. The Germans were using zinc, silver, gold and copper for filters. Soon the American manufacturers were producing 20" machines, and then followed a serious study of filtration. Henry Schmitz was among the first to recommend copper because of the more homogeneous beam. Albert Bachern was among the first to carefully plot intensity and quality. Failla and Quimby were also active in this field of investigation. Hauser of Buenos Aires advocated his composite filter of tin, copper and aluminum. Emery and Mudd at the California Institute of Technology used steel, lead and aluminum for 800 to 1000 Kv therapy.

Various attempts have been made to describe quality of radiation. Physicists recognized early that the x-ray beam was not homogeneous, and that no wave length could be shorter than that produced by the highest voltage, hence the term KvP. Duane, Kauffman and others attempted to describe the quality of the beam by the term, effective wave length, designating a wave length of monochromatic radiation which would represent the average characteristic of the entire beam. There was considerable disagreement as to the method of determining this factor, so in 1937 at the Fifth International Congress of Radiology, half value layer was adopted as the method of describing quality. The amount of aluminum or copper required to reduce the intensity of the beam one half, is the H.V.L. and should always be given in mm. of al. or cu. at the KvP used. H.V.L. may be determined accurately by any radiologist or physicist even though his instrument for measuring intensity is considerably inaccurate.

**Biological Effects**

Probably the first record of biological investigation of the effects of x-rays is contained in a report by Kibbee in 1897 when he reported on the microscopic changes in the skin affected by x-rays. The early therapists recognized the early effect of x-rays on the hair follicles and used this effect as a guide. Many theories were advanced, several were very close to the present accepted views. Bergonie and Trebondeau’s statement in 1906 that the sensitivity varies directly with the reproduction capacity of the cell and inversely with its degree of differentiation has been accepted in a general sense; it is now known that there are many exceptions. As early as 1899 Schandinn pointed out that dehydrated cells are more resistant to irradiation.

It was not until the second decade that intensive studies on radiobiology were attempted. With the improved equipment and the acceptance of radiation therapy as a medical specialty, large medical centers established research departments manned by trained scientists who have cooperated with the radiologist and with the pathologist and have provided much valuable information. Colwell and Russ reported on the effects of irradiation on normal tissues. Ewing’s detailed work on the effects of irradiation on
different types of cancer is outstanding. Broder's classification of cancer cells according to grade of malignancy is of undoubted prognostic value. MacCarty has also performed outstanding work on the histology of the malignant cell. Alter has studied the effects of irradiation on cancer tissues. All of the present accepted information points to electrochemical changes in the protoplasm of the cell and especially the nucleus—all brought about by ionization.

Closely related to biological effect is the study of absorption. The effect of voltage was easily recognized. The use of filters increased the depth effect. The increased skin effect with large fields was recognized early. J. J. Thomson and C. C. Barkla reported on careful investigations of back scatter in 1911. Compton's work on absorption in 1920-1922 was an outstanding advance. Otto Glasser's isodose curves were a great aid in calculating depth dosage. Edith Quimby's outstanding work on back scatter published in 1939 is of inestimable value and has now replaced all former calculations. There still remains the need of more satisfactory estimation of depth dose.

**Methods of Administration**

In the very beginning, x-ray therapy was applied in divided doses, daily or at longer intervals until a result was obtained or erythema of varying degrees appeared. Later, courses or series of exposures were given in an attempt to standardize technique. But in the early days the inability to duplicate exposures on the same machine let alone attempting to deliver identical amounts with different machines made this impossible. The result was a hodge-podge of ideas and methods, the results of which were often tragic or at least disappointing. The Boston Medical Journal, January, 1905, said, "Whereas, we had hoped to find in the x-ray a cure for cancer, have found instead that it is a cause of cancer instead of a cure."

Much of the early therapy was attempted by laymen and physicians who knew absolutely nothing about x-rays. I shudder when I think of my own first attempts at therapy in 1916-1917. By 1918 the literature contained some reports on dosage based on the use of the Coolidge tube. Voltage (spark gap), milliamperage, filter, distance, time and field size were the factors emphasized. Next came multiple ports and crossfiring. Then came the influence of Sietz and Wintz, who in 1920 published reports of their method of massive dose technique. Many therapists attempted this method but the systemic reactions were so severe that it was discontinued and a modification adopted whereby multiple ports were used, the maximum dose given through each port at intervals of three to ten days. Also in 1920 Kingery reported on the saturation method for the treatment of deep lesions. Then in 1930 we began to hear of the protracted fractional method of Coutard, various modifications of which are in common use today. This method employs very heavy filtration, the treatments are given in relatively small amounts daily or twice daily.
through multiple small ports over an extended period of time. The periodic epithelial and epidermal reactions are a guide to the effect upon the tumor and upon the tumor bed. Preservation of a normal tumor bed is one of the principal objects of the method while at the same time an enormous amount of radiation is delivered to the tumor which is destroyed. The use of heavy filtration permits severe skin reactions which heal without permanent damage to the derma and subdermal tissues. Various attempts were made to describe dosage based upon its effect upon the skin. The “erythema dose” and the “threshold erythema dose” came into use. There was a wide range in the amount of radiation used to produce these effects. Even after the T.E.D. was defined and accepted there still remained a considerable difference in the amount used. After the universal adoption of the roentgen as a unit of quantity, an average has been struck for what is accepted as a T.E.D. for the various qualities of radiation now in common use.

Present day roentgen therapy is a far cry from that of twenty years ago, when treatments were given with diagnostic machines and universal Coolidge tubes, voltage measured with a spark gap, aluminum and sole leather used for filters, open lead-glass bowls for protection of the patient and the operator, and dosage calculated in milliampere minutes or milliampere hours. Skin damage was frequent in attempting to give an adequate total dose for deep-seated lesions and rarely accomplished. Tumors were undertreated and the skin overtreated. The courts were often crowded with suits for malpractice arising from x-ray injuries. The public became fearsome of x-ray. We still must combat entrenched notions that x-rays spread cancer and even cause cancer.

Protection of the patient and operator has been the subject of discussion off and on since the beginning. Many of the early workers recognized this need, but the enthusiasm of the users and the paucity of knowledge and understanding of x-rays and their effects caused most operators to disregard protection to a large extent. In 1915 the British Roentgen Society passed a resolution directing the Council of the Society to establish rules for the protection of x-ray operators and patients. The World War prevented completion and in 1921 because of reports of a great many deaths from aplastic anemia, probably the result of over-exposure by operators during the press of work in the hospitals and at dressing stations incident to the war, recommendations were prepared by the Roentgen Ray Protection Committee of the American Roentgen Ray Society and adopted in 1922, thus setting up the legal status of x-ray protection. Now, instead of the patient being weighted down and smothered by heavy x-ray protection material, the tubes are x-ray protected. Only the port of entry is exposed. The operator now stays out of the therapy room, the walls of which are ray proof. Standards have now been devised and adopted at the International Congress of Radiology in 1928 and revised in 1937. Those of the U. S. Bureau of Standards are revised annually. Modern therapy equipment is designed only for therapy. It is shockproof and
x-ray protected. Most modern equipment utilizes some means of cooling the anode with either oil or water. Shockproof cables permit the high voltage current to be conducted to the tube from an adjoining room so that no high tension current is exposed in the therapy room, hence no odors and no noise, or the equipment is sealed and self-contained. The Maximar type is an example. Automatic shutters, distance determining, and field limiting cones are a part of all modern equipment. The control stand contains prereading voltmeters, center grounded milliammeters, interval timers, rheostats and autotransformers for accurate current and voltage regulation. Constancy meters or integrating meters are connected with ionization chambers constantly in the beam. Modern therapists have their equipment calibrated as to intensity and quality output at regulated intervals by a consulting physicist. Recognized therapists are trained in the fundamentals of radiation physics, radiobiology, and the diagnosis of neoplasms in addition to complete medical and surgical training. Men certified as Roentgenologists or Radiologists by the American Osteopathic Board of Radiology meet the highest standards, standards of which they can be justly proud. Eminent members of the medical profession have expressed amazement at the completeness and comprehensiveness of the examinations given our diplomates.

The Future of Radiation Therapy

The future development of radiation therapy lies in several closely allied fields. Progress in physics and engineering has suffered a temporary lull because of defense activities. However, a certain amount of work continues at the California Institute of Technology, the University of California, Massachusetts Institute of Technology, the University of Chicago, and other centers. Work is now under way to produce x-rays at 2000 to 4000 Kv. The speed of the electrons in the cathode stream has already closely approached the speed of light when operating a tube at 1250 KvP. What will happen when the voltage is raised to 4000 KvP? Will the speed of the electron exceed the speed of light? What sort of radiation will be produced?

After the defense production slows down, manufacturers will soon develop new equipment. The self-contained equipment has many advantages and some disadvantages. We can expect many refinements in equipment. What is now known as superficial x-ray will be limited to 85 to 100 KvP. Intermediate therapy from 140 to 200 KvP and deep therapy at 250 KvP. Supervoltage will range from 400 to 4000 Kv with 1000 Kv equipment as common as 400 Kv now is because sealed tubes have already been constructed with constant vacuum for operation at 1000 KvP. The Grenz ray is becoming more popular among dermatologists and Chaoul or contact therapy is popular in some centers. There is probably room for improvement in both of the modalities.

Much work remains to be done in determining accurate depth dose measurements. Depth dose is now calculated as a certain percentage of
surface dose (primary beam plus back scatter) or by attempting to measure ionization within the mass by means of an air wall chamber, which as soon as it is imbedded is no longer an air wall chamber. I predict that a method of determining depth dose will be a measurement of fore-scatter by some means simulating a reversal of Quimby's classical work of backscatter with an extrapolation chamber, in which the thickness of the absorbing medium can be varied, the beam passing through the absorbing medium into the thin chamber beyond. The tissue roentgen is to be re-defined and will supplant the roentgen in calculating and recording dosage.

I predict that agents will be developed which when administered to a cancer patient will enhance the action of radiation, making it more effective and more selective. The work already done on colloidal gold has pioneered this field.

With the rapid advance in colloidal and biologic chemistry and with our increasing knowledge of the action of catalysts in the form of vitamins, enzymes, hormones, and certain minerals, we may expect almost anything to happen in the field of cancer therapy. The electron microscope may shed new light on the cause of cancer or upon the internal architecture of the cell which may alter our basic views on cancer. This subject is being approached from many angles. Vast amounts of money have been used to set up foundations for research. We frankly admit that radiation therapy has not completely answered the problem of a cure for cancer.

Our own future rests largely with ourselves. For the time being we can only follow the recognized scientists. We must keep abreast of all advancement of knowledge as applied directly or indirectly to radiation therapy. We must aid those in organized Osteopathy who are leaders in education and especially those who are attempting to obtain endowments for our colleges and hospitals, in order that we, too, may take part in research. We must constantly improve ourselves and our equipment. We must continue to train capable men in our chosen field. We must hold our specialty at a high level among other specialties and endeavor to obtain the greatest cooperation with all other departments, always keeping the best interests of the patient foremost.

We must work towards the complete separation from financial interests in the practice of Radiology by all hospitals, clinics, individuals or groups. No radiologist should be exploited by another party any more than a surgeon, a urologist or an internist. Radiology is one of the most highly specialized branches of practice. The ideal situation is for the Radiologist to own his equipment; he may rent it, however, the same as he may rent his space, but the hospital, clinic, surgeon or group has no right to a percentage of his fees.

I look forward with much enthusiasm toward the founding of the American Osteopathic College of Radiology. The limiting of membership to diplomates of the Board of Radiology is an excellent beginning. I like the idea of reserving Fellowship in the College for those members of out-
standing accomplishments, attainments or service to the profession. The founders are wise in holding their meeting, at least during the early formative years, in conjunction with the American Osteopathic College of Surgeons. The Founding Committee, Drs. Eugene Kraus and Armande Porias are to be congratulated on their careful work. Dr. Karibo is to be congratulated on the splendid program he has prepared for this our natal day.

And now, may I express my sincere and humble appreciation of the high honor accorded me by the program Chairman in asking me to give this, the first Lloyd Lecture in honor of that lovable, capable, outstanding teacher and leader, Paul T. Lloyd.

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By its nature, the disc to some extent determines the character of motion at the facet articulation, and conversely, alterations at the facet probably exercise some influence on disc structure and physiology. Under normal conditions the disc has much to do with determining the mechanical pattern of vertebral motion; and when pathological changes occur in it, the part it might play in altered spinal mechanics must be evaluated. Observation of changes taking place between adjacent vertebral bodies should contribute to a better understanding of spinal mechanics. It was the purpose of this study to observe radiographically the changes in interbody spacing occasioned by flexion-extension motion in five cervical vertebral segments.

In the previous report of this series a radiographic technique for studying vertebral mechanics was presented. The same technical procedures used for that study were applied in the one reported here and description of the technical procedures will be omitted in this paper. The clinical and non-clinical subjects used for this study were the same as those used in the previous one, and all other conditions relating to the two investigations were identical.

To arrive at a mathematical value useful in expressing interbody spacing and the changes occurring in it during flexion-extension motion, the algebraic sums of the anterior and posterior E.I.V. lengths were utilized. In the instance of each interspace, this value is double the mean of the two distances between adjacent body points measured at right angles to the intersegmental transverse at the intersection of this line with the lateral intersegmental lines. Inasmuch as there is great variation in the arcs of the body surfaces between the anterior and posterior body points, this value does not represent double the actual disc thickness, but because of the use of a constant index of extension the values can be utilized to compare changes in the interbody spaces for a given segment. Because the disc is the structure interposed between adjacent vertebral bodies, changes occurring in the interbody space represent in general the changes occurring in the disc. For this reason the term "compression" will be used to indicate any decrease in the space between vertebral bodies, and the term "decompression" used to indicate any increase in interbody spacing.

Study of Twenty Non-Clinical Subjects (College Students)

Totals of anterior and posterior E.I.V. measurements were determined for the second to sixth cervical segments in the twenty college student group in order to arrive at an average disc spacing in terms of extended measurement. The neutral position films were used for this determination. Results are shown in table 1, and are expressed in millimeters and in segmental percentage of total spacing. It can be seen that there was little significant difference among the several segments, either as to the means or ranges.

TABLE 1
Interbody spacing in cervical segments of twenty non-clinical subjects measured in the neutral position.

<table>
<thead>
<tr>
<th>Seg.</th>
<th>Extended Measurement in Millimeters</th>
<th>Percentage of Total Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>av.</td>
<td>range</td>
</tr>
<tr>
<td>2</td>
<td>8.4</td>
<td>7.0 — 10.5</td>
</tr>
<tr>
<td>3</td>
<td>7.9</td>
<td>6.0 — 9.5</td>
</tr>
<tr>
<td>4</td>
<td>7.8</td>
<td>6.0 — 10.0</td>
</tr>
<tr>
<td>5</td>
<td>8.5</td>
<td>6.0 — 11.0</td>
</tr>
<tr>
<td>6</td>
<td>8.6</td>
<td>6.5 — 11.5</td>
</tr>
</tbody>
</table>

Totals of the five segment interspaces were determined for each of the positions, flexion, neutral, and extension, in order to observe changes induced when the cervical column was flexed and extended. These changes are shown in table 2. The averages for all twenty subjects shown at the bottom of each column indicate that in the movement from neutral to flexion position there was a general compression of discs amounting to 3 per cent of the total of disc thicknesses obtaining in the neutral position. In the movement from neutral position to extension there was a decompression of 7 per cent of the neutral value, and from complete flexion to complete extension there was a decompression of 10 per cent over the flexion value. The columns indicating changes in each subject show that in neutral to flexion there were seven subjects that did not conform to the general compression indicated by the average for the twenty subjects, but instead actually showed an increase in spacing. In neutral to extension movement, one subject evidenced compression rather than decompression. In complete flexion to extension all subjects evidenced an increase in interbody spacing. These changes were analyzed in terms of individual segments and results are shown in table 3. Examination of the results indicates that individual segments show no characteristic behavior, there being a rather even distribution of values from the five segment group in all changes and in all movements.
TABLE 2

Changes in interbody spaces during flexion-extension movement. Percentages relate to the neutral position values in movements from the neutral position, and to the flexion position values in flexion to extension movement. Increase +, decrease −.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Neutral to Flexion</th>
<th>Neutral to Extension</th>
<th>Flexion to Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>per cent</td>
<td>per cent</td>
<td>per cent</td>
</tr>
<tr>
<td>1</td>
<td>+1</td>
<td>+9</td>
<td>+8</td>
</tr>
<tr>
<td>2</td>
<td>−2</td>
<td>+5</td>
<td>+7</td>
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<td>+14</td>
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</tr>
<tr>
<td>8</td>
<td>+1</td>
<td>+11</td>
<td>+10</td>
</tr>
<tr>
<td>9</td>
<td>−4</td>
<td>+5</td>
<td>+9</td>
</tr>
<tr>
<td>10</td>
<td>−1</td>
<td>+7</td>
<td>+8</td>
</tr>
<tr>
<td>11</td>
<td>+1</td>
<td>+5</td>
<td>+4</td>
</tr>
<tr>
<td>12</td>
<td>−6</td>
<td>−2</td>
<td>+4</td>
</tr>
<tr>
<td>13</td>
<td>−6</td>
<td>+5</td>
<td>+12</td>
</tr>
<tr>
<td>14</td>
<td>−2</td>
<td>+6</td>
<td>+8</td>
</tr>
<tr>
<td>15</td>
<td>+1</td>
<td>+14</td>
<td>+13</td>
</tr>
<tr>
<td>16</td>
<td>+5</td>
<td>+8</td>
<td>+3</td>
</tr>
<tr>
<td>17</td>
<td>+1</td>
<td>+6</td>
<td>+5</td>
</tr>
<tr>
<td>18</td>
<td>−3</td>
<td>+8</td>
<td>+11</td>
</tr>
<tr>
<td>19</td>
<td>0</td>
<td>+9</td>
<td>+9</td>
</tr>
<tr>
<td>20</td>
<td>+1</td>
<td>+12</td>
<td>+11</td>
</tr>
<tr>
<td>Average</td>
<td>−3</td>
<td>+7</td>
<td>+10</td>
</tr>
</tbody>
</table>

TABLE 3

The number of segments in which compression (−), decompression (+), or no change (0) occurred in the three movements in twenty subjects.

<table>
<thead>
<tr>
<th>Seg.</th>
<th>Neutral to Flexion</th>
<th>Neutral to Extension</th>
<th>Flexion to Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>−</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Totals (per cent)</td>
<td>50</td>
<td>28</td>
<td>22</td>
</tr>
</tbody>
</table>
TABLE 4

Comparison of disc thickness expressed in millimeters of extended interbody measurement in each segment between 60 subjects and 33 controls. All measurements made in the neutral position. Subject measurements made before manipulation.

<table>
<thead>
<tr>
<th>Seg.</th>
<th>Age Group I (18-34)</th>
<th>Age Group II (35-54)</th>
<th>Age Group III (over 55)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>mm.</td>
<td>mm.</td>
<td>mm.</td>
</tr>
<tr>
<td>Subjects (60)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7.0</td>
<td>5.5 - 9.5</td>
<td>7.1</td>
</tr>
<tr>
<td>3</td>
<td>7.6</td>
<td>4.0 - 13.0</td>
<td>7.2</td>
</tr>
<tr>
<td>4</td>
<td>7.2</td>
<td>4.0 - 10.0</td>
<td>7.0</td>
</tr>
<tr>
<td>5</td>
<td>7.2</td>
<td>5.0 - 9.0</td>
<td>6.6</td>
</tr>
<tr>
<td>6</td>
<td>7.2</td>
<td>5.5 - 10.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Controls (33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8.4</td>
<td>7.0 - 10.5</td>
<td>7.1</td>
</tr>
<tr>
<td>3</td>
<td>7.9</td>
<td>6.0 - 9.5</td>
<td>7.8</td>
</tr>
<tr>
<td>4</td>
<td>7.8</td>
<td>6.0 - 10.0</td>
<td>7.8</td>
</tr>
<tr>
<td>5</td>
<td>8.5</td>
<td>6.0 - 11.0</td>
<td>7.1</td>
</tr>
<tr>
<td>6</td>
<td>8.6</td>
<td>6.5 - 11.5</td>
<td>7.2</td>
</tr>
</tbody>
</table>
TABLE 5

Segmental changes in disc thickness, in flexion and extension, expressed as the number and per cent of total discs which were decompressed (+), compressed (−), or unchanged (0) when the cervical column was carried through flexion-extension movement. Based on findings in 60 subjects (patients) and 33 controls comprising the combined three age groups. Subject measurements made before manipulation.

<table>
<thead>
<tr>
<th>Seg.</th>
<th>Neutral to Flexion</th>
<th>Neutral to Extension</th>
<th>Flexion to Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>−</td>
<td>0</td>
</tr>
<tr>
<td>Subjects (60 patients)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>38</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>38</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>37</td>
<td>23</td>
</tr>
<tr>
<td>Age Groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>23</td>
<td>38</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>42</td>
<td>18</td>
</tr>
<tr>
<td>Controls (33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>46</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>36</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>Age Groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>33</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>24</td>
<td>15</td>
</tr>
</tbody>
</table>
The selection of the sixty clinical subjects used and the procedures carried out have already been referred to.

Measurements of the interbody spacings in the clinical subjects and controls of the three age groups were made and are shown in Table 4. It will be seen that with two exceptions (one interspace in age group two, and one interspace in age group three) the average disc values of the subjects are uniformly less than those of the controls. This suggests either that the discs were, on the average, thinner in the patient group, or that the patient group had cervical columns substantially shorter than the controls. In order to rule out the latter, the distances between intersegmental centers in the neutral position were determined and their total in each subject used to indicate total column length. The clinical subjects were found to have these five segments of the cervical column 3.3 per

### TABLE 6

Quantitative changes in disc thickness expressed as percentage ranges of thickness in neutral or flexion positions. In the movements from neutral position to flexion and from neutral position to extension the values represent percentage decompression or increase (+) and compression or decrease (−) of disc thickness in the neutral position. In the movement from complete flexion to complete extension figures represent percentage (+ or −) of disc thickness in the flexion position. Composite of three age groups (18-34), (35-54), (over 55).

<table>
<thead>
<tr>
<th>Movement</th>
<th>Seg.</th>
<th>60 Subjects Age Groups I, II, and III</th>
<th>33 Normals Age Groups I, II, and III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral to Flexion</td>
<td>2</td>
<td>− range + 25 − 70</td>
<td>− range + 23 − 36</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>46 − 44</td>
<td>18 − 31</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>40 − 33</td>
<td>33 − 36</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>50 − 44</td>
<td>20 − 30</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>44 − 60</td>
<td>37 − 33</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>41 − 50</td>
<td>26 − 35</td>
</tr>
<tr>
<td>Neutral to Extension</td>
<td>2</td>
<td>28 − 42</td>
<td>28 − 31</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>21 − 80</td>
<td>20 − 31</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>31 − 50</td>
<td>25 − 43</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>27 − 150</td>
<td>25 − 39</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>42 − 200</td>
<td>33 − 90</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>30 − 104</td>
<td>26 − 47</td>
</tr>
</tbody>
</table>
cent shorter than the controls, while the total disc spacing in the subjects was 10.7 per cent less than in the controls.

The changes that occurred in each disc in every subject and control are shown in table 5 under the headings of compression, decompression, and no change. The findings recorded seem to indicate that there is no uniformity in the changes of discs when flexion-extension movement is produced, but that each disc seems to react according to the sum total of factors governing its own individual mechanics. It would seem to be impossible in light of present knowledge to formulate any standard change and call it "normal."

Certain interesting facts concerning the behavior of the control group indicated in table 5 might be mentioned. In neutral to flexion movement, the second, third, and fifth segments showed disc decompression oftener than the other segments, with the fourth showing it least often. In the same movement, compression was fairly evenly divided among the five segments, but with the fourth segment disc again being the least changed. The fourth disc was the most stable in neutral to flexion movement. In contradistinction to this, the fourth segment contributed most often to decompression in the movement from neutral position to extension.

No reference has been made thus far to the amount of compression or decompression which took place. It was considered of value to study this point. A basis for expressing these changes had to be selected which would smooth the differences which existed in disc thicknesses among the five segments in one individual, and among those of different individuals. The basis is that of expressing the changes that occurred in the two movements from neutral position as percentage of the neutral position disc value, and the changes that occurred between full flexion and full extension as percentage of flexion spacing. Results are shown in table 6.

All of the data thus far presented concerning the disc in the subject and normal control have had to do with conditions as they existed before manipulation was applied. It now is important to investigate the various changes which were found to have occurred after manipulation was applied, according to the circumstances which have already been enumerated relative to treatment.

In table 7 are shown the changes which occurred in 24 subjects following manipulation. It was found that after manipulation some of the subjects gave total disc thicknesses, for the five segments, less than the originals, while others gave greater values. For this reason, the findings are presented as the number, percentage of total number, and average millimeter change showing increase and decrease. In one subject, no change in total disc thickness occurred. The first values shown in table 7 are those of the changes in the combined three age groups. The figures show that half the subjects decreased in total disc thickness while approximately half increased. This indicates that in this group at least, there was no characteristic change in the interbody spacing following manipulation. It will be observed, however, that the average change in those that decreased was almost twice as great as in those that increased in thickness,
TABLE 7

Comparison between the total disc thickness of five cervical segments before and after manipulation measured in the neutral position. Based on 24 subjects, 8 in age group I, 10 in age group II, and 6 in age group III. The composite findings for the three groups and for each age group separately are shown as the number, percentage of total, and average change in millimeters.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Decrease</th>
<th></th>
<th></th>
<th>Increase</th>
<th></th>
<th></th>
<th>Unchanged</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no.</td>
<td>per cent</td>
<td>average mm.</td>
<td>no.</td>
<td>per cent</td>
<td>average mm.</td>
<td>no.</td>
</tr>
<tr>
<td>Composite (I, II, III)</td>
<td>12</td>
<td>50</td>
<td>2.9</td>
<td>11</td>
<td>46</td>
<td>1.6</td>
<td>1</td>
</tr>
<tr>
<td>Group I (18-34)</td>
<td>5</td>
<td>63</td>
<td>2.6</td>
<td>3</td>
<td>37</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Group II (35-54)</td>
<td>3</td>
<td>30</td>
<td>3.8</td>
<td>6</td>
<td>60</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td>Group III (over 55)</td>
<td>4</td>
<td>67</td>
<td>2.2</td>
<td>2</td>
<td>33</td>
<td>2.5</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 8
Segmental alterations in disc compression (−) and decompression (+) following manipulation. Neutral to flexion and neutral to extension changes based on comparison to disc thickness in neutral position, flexion to extension changes based upon comparison to flexion position. Figures represent composite of three age groups (18-34), (35-54), (over 55) and five segments. Based upon study of 24 subjects (120 segments) having recheck studies following manipulation.

<table>
<thead>
<tr>
<th>Movement</th>
<th>Original Decompression (+)</th>
<th>Original Compression (−)</th>
<th>Original No Change (0)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Neutral to Flexion</td>
<td>46</td>
<td>23</td>
<td>14</td>
</tr>
<tr>
<td>Neutral to Extension</td>
<td>63</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Flexion to Extension</td>
<td>58</td>
<td>25</td>
<td>17</td>
</tr>
</tbody>
</table>

TABLE 9
Change in total column length of five cervical segments in neutral position following manipulation in twenty-four subjects, 8 in age group I, 10 in age group II, and 6 in age group III.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Increased</th>
<th>Decreased</th>
<th>No Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no.</td>
<td>per cent</td>
<td>av. increase mm.</td>
</tr>
<tr>
<td>Group I (18-34)</td>
<td>1</td>
<td>12</td>
<td>1.00</td>
</tr>
<tr>
<td>Group II (35-54)</td>
<td>3</td>
<td>30</td>
<td>0.50</td>
</tr>
<tr>
<td>Group III (over 55)</td>
<td>2</td>
<td>33</td>
<td>0.75</td>
</tr>
<tr>
<td>Composite</td>
<td>6</td>
<td>25</td>
<td>0.67</td>
</tr>
</tbody>
</table>
which would seem to indicate that if any general trend is to be looked for from these studies, it must be toward the side of decreased disc spacing following manipulation. Without being able to make detailed study along the line, it is interesting, nevertheless, to compare this tendency toward lessened disc thickness with the changes in the disc which Burns has shown to have existed in the lesioned laboratory animal. The dominant change was one affecting water balance and consisted chiefly of edema or swelling in the early stages of the lesion. In our present studies, are we encountering reduction of edema following manipulation when we find this trend toward lessened disc spacing? The answer cannot definitively be given, for such a condition as muscle tension variations and many other conditions must also be considered, but the findings are at least interesting.

Neither subjects nor controls presented any definite pattern so far as segmental response to flexion-extension movement is concerned in the way in which compression (−) or decompression (+) of discs took place. We might well ask what changes are produced in segments following manipulation—do those which show compression in neutral to flexion movement before manipulation still show the same change following manipulation or will they shift to decompression or to no change? The basis for comparison has already been established as the neutral position disc thickness in movements from neutral to flexion and to extension, and the flexion position disc thickness in complete flexion to extension movement. A segment which evidenced decompression of its disc in neutral to flexion movement before manipulation might show one of three conditions after manipulation; either the disc will still show decompression, will show compression, or show no change in relation to the neutral thickness. The five segments in each of the twenty-four subjects were examined for these changes in the three movements neutral to flexion, neutral to extension, and flexion to extension, and the results are set down in table 8.

The data which have just been presented relative to various changes in the disc have been limited to comparisons of individual segments and the relation of individual segments to total disc values. By comparing the total column lengths before and after manipulation, it was possible to approach disc changes from another angle.

In part I, the method of measuring total column length was presented. This consisted in finding the four distances between the five intersegmental centers. The total of the four numbers, in millimeters, gives a value which can be called total column length (T.C.L.) for the five segments under study. Variations in the T.C.L. could be produced only by variations in the interbody (disc) spacing inasmuch as the vertebral bodies are incapable of compression or decompression under ordinary circumstances.

The T.C.L. in each of the twenty-four rechecked subjects before and after manipulation were compared to determine whether there were any significant changes produced by treatment. The results are shown in table 9. No attempt will be made to set forth the factors responsible for these changes, for there was nothing in the study to reveal the agencies through which the disc changes were brought about.
MICROLITHIASIS: REPORT OF A CASE

H. WILLARD STERRETT
Professor of Urology

Mr. E. D. N., a male machinist, age 19, consulted the writer on October 10, 1943, complaining of hematuria. He stated that he had tried to get into the armed forces and had been rejected because of the presence of albumin and blood in the urine.

His past personal history had been essentially negative except for attacks of measles and chickenpox. No other illnesses were noted, and there had been no operations or accidents of record. His family history was entirely negative, both parents being alive and well. No history on either side was elicited as regards tuberculosis, cardiovascular disease, or cancer. In every respect he had been an exceptionally well and athletic young man.

With a history of hematuria it was deemed advisable to do cystoscopy and secure a pyelogram if necessary, and he was accordingly admitted to the hospital on October 22, where this procedure was done without difficulty under local analgesia. The bladder was entirely negative. Ureteric specimens revealed both sides to have an alkaline urine (pH 7.5) and were positive 2 plus for albumin. The left ureteric specimen was otherwise essentially negative except for a rare granular cast. No pus was found. The right ureteric specimen showed phosphates, an occasional pus cell, and blood too numerous to count. Summary of the pyelogram was as follows: "Pathologic variations are observed in the minor division of the cephalic region of the right kidney suggestive of a destructive or inflammatory process of some duration. The papillary limits of the cephalic calyx are rounded, blunted, but regular. The middle calyx on the right shows altered relief and small projections of contrast medium beyond the normal limits of the calyx prevail without indications of over-distention of the kidney by contrast fluid. These findings are again quite suggestive and indicative of inflammatory pathology with cortical damage prevailing.

"The findings referable to the right kidney cannot be interpreted on the basis of neoplasm. I believe they are inflammatory or infective, and renal tuberculosis must be given consideration on the basis of present findings. The left kidney is essentially negative."

Following this cystoscopy the patient left the hospital, and later that evening he was seized with severe pain in the right side which became so severe that it required administration of morphia. He was accordingly readmitted to the hospital the following day. Depropanex was administered and fluids forced, and he was discharged the following day.

Cultures which had been taken at the time of cystoscopy were returned.
No organisms were found, and no acid fast bacilli were reported. Patient was then readmitted on October 26 and further studies made. The blood picture at this time showed 3,890,000 red blood corpuscles per cu. mm.; hemoglobin 65.3 per cent (10 gm. per cent); coagulation time 5 minutes; 13,000 leucocytes per cu. mm., of which 82 per cent were polymorphonuclear neutrophiles, and 18 per cent lymphocytes (2,340 per cu. mm.).

Sections of the kidneys (H and E) showing the calcareous deposits in the nephrons, the distention of the spaces within the capsules of Bowman, and the distention of the tubular apparatus.

Urinalysis was essentially the same as on the preceding admission except at this time the urine was acid (pH 5), and an occasional urate crystal found. The Wassermann and Kahn reactions on blood were both negative. Blood sedimentation by the method of Cutler was rapid, being 28 mm. in 60 minutes with a drop to 20 mm. in 20 minutes. Phosphatase was
4.7 units per cent, inorganic phosphorus 4.5 mgm. per cent, blood calcium 9.0 mgm. per cent, and urea nitrogen was 16.8 mgm. per cent. Blood pressure at this time was 158/88.

In view of the above findings and the fact that the lesion had been localized in the right side, and together with the fact that despite therapy the loss of blood continued, the patient was submitted to surgical intervention. On November 2 a right nephrectomy was done under continual spinal analgesia. Procaine in the amount of 300 mgm. was administered. The operation lasted thirty-five minutes. There was little shock and the patient was sitting up on the third day, being discharged from the hospital on the tenth postoperative day. The pathological report was as follows: "The kidney submitted weighed 240 grams. It measured 12.5 x 6.5 x 5 cm. and presented a very distinct fetal lobulation. The capsule stripped easily and the cut surface was exceedingly pale.

"Sections of the kidney show swollen glomeruli and a considerable number show distention of the space of Bowman. The tubular epithelium is swollen and in certain regions has obliterated the tubular lumen. The most striking feature in these sections is the presence of small discrete patches of calcification scattered throughout the cortex. These areas are apparently directly in the lumina of the nephrons. Here and there is a tendency to stratification of these materials, and in certain sections they are associated with round cell infiltration in the supporting stroma. There is no suggestion of specific infection, nor do we demonstrate neoplasm.

"Pathological diagnosis. Fetal lobulation of the kidney. Microlithiasis."

This case is reported because of its unusual characteristics and the paucity of literature on the subject. Joly discusses briefly the formation of crystals in the kidney. Randall in recent literature discusses the "node" which he believes to be a factor in urinary lithiasis. Whether this case was a case of calculus disease due to vitamin deficiency or whether it was a case due to hemorrhagic infarct is open to question. Certainly since hypertension was present it would seem possible that microscopical hemorrhagic areas with subsequent calcification of infarct could have had a part in the production of microlithiasis.
ASPHYXIA DUE TO REGURGITATED FOOD BLOCKING THE RESPIRATORY TREE: AUTOPSY REPORT OF A CASE*

Otterbein Dressler
Professor of Pathology in the College, and Special Deputy Coroner,
City of Philadelphia

In a previous report1 attention was called to the controversy concerning status thymicolymphaticus. An attempt was made to show that thymic death might sometimes be a cloak behind which to hide ignorance as to the cause of sudden death. The case to be reported here might have been one of thymic death, and might have been so reported. However, we are inclined to feel that the actual mechanism was asphyxia due to mechanical blockage of the respiratory tree.

Autopsy No. 44-1027
Died: 4/3/44, 12:40 p.m.
Autopsy: 4/3/44, 4:00 p.m.
At the City Morgue

Clinical Data

“The child was put out in front of house in coach. When mother went to see child she found him lying on his stomach apparently dead from suffocation. Uncle took him to hospital, dead on arrival.”

External Examination

The body was that of an infant male, said to be two and one-half months old. The crown-rump length was 39 cm. and the crown-heel length 58 cm. The body throughout was excessively pale. The anterior fontanel was open quite wide. The posterior fontanel was very small. The eyes were bright, shiny, leading one to believe that death was very recent. The pupils were equal in size. There was a very scant crop of hair upon the cranium. Large quantities of food exuded from the nose and the mouth. No lymph adenopathies could be palpated anywhere on the body. There were no evidences of trauma and no evidences of caustic poisoning.

Internal Examination

The thymus gland was somewhat larger than average for this age, weighing 24 grams. A few petechial hemorrhages could be demonstrated

* Case reported through the courtesy of Dr. Benjamin Gouley, Chief Coroner's Physician, City of Philadelphia.
in the thymus, in the lungs, and in the pericardium. These spots were not numerous and required rather close inspection for their identification.

Less than 25 cc. of amber fluid was found in the pericardial sac. The greatest diameter of the heart was 6.5cm. The greatest diameter of the thorax at the upper level of the diaphragm was 11 cm. with a cardio-thoracic ratio of 6.5/11. There were no valvular lesions and no septal defects of the heart. The foramen ovale was probe patent. The ductus arteriosus was sufficiently patent to admit a grooved director.

The structures of the neck were dissected with the larynx, trachea and bronchi opened. The larynx, trachea and bronchi, particularly the latter, were filled with food quite the same as that found in the stomach. There were no esophagotracheal fistulae. There were no noteworthy changes in the lungs.

The esophagus presented no lesions.

The stomach was greatly distended with a recent feeding. From the condition of the material in the stomach and the fact that the urinary bladder was empty we are led to believe that the infant died very shortly after feeding and being placed at rest.

There were no lesions of the intestines.

The liver and gallbladder presented no lesions.

The pancreas presented no noteworthy lesions.

The spleen measured 5 x 3.5 x 2.5 cm.

The urinary bladder was empty.

The kidneys presented fetal lobulation and measured respectively, right and left, 5 x 3 x 2 cm. and 5 x 3 x 1.5 cm. There were no noteworthy lesions.

The suprarenal glands presented no noteworthy lesions and while they were not weighed, it was our impression at autopsy that they were comparatively small rather than large.

The external genitalia presented no lesions.

The excess pallor of the body and its somewhat “well fed” appearance led us to suspect, before the cavities were opened, that death might have resulted from status thymicolymphaticus. Other than the somewhat enlarged thymus we were unable to demonstrate any lymphoid hyperplasia in the rest of the body. Also, we took into account the growing impression that status thymicolymphaticus might be something more frequently talked about than actually seen, since there is some doubt in certain quarters that such a syndrome as a mechanism of death even exists. In this instance, finding large quantities of food in the respiratory tree, we are led to believe that perhaps that might have been the mechanism of asphyxia reserving the impression, however, that if the position of the child had been different in his bed and if the thymus had not been large, this fatal accident might not have occurred.
Microscopy

Sections of the thymus gland show a good architecture compatible with the age, as reported, of the infant. Large numbers of corpuscles of Hassall are identified lying chiefly within the germinal follicles of the lymphatic structures. It would be difficult to say that there is any excess of these corpuscles.

Sections of the liver show a very good glycogen reserve, compatible with sudden death after feeding.

Sections of the suprarenal glands present no noteworthy changes.

Anatomical Diagnosis

Patent foramen ovale
Patent ductus arteriosus
Obstruction of bronchial tree
Asphyxia

Cause of Death

Asphyxia due to regurgitated food blocking respiratory tract.
Contributory: Large thymus.

Summary

A case of asphyxia due to mechanical blockage of the respiratory tree by regurgitated food is reported by autopsy findings.

Bibliography

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