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The President, Henry R. Wharton, M.D., in the Chair.

GANGRENE OF THE SCROTUM.

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Among the different organs of man in which gangrene occurs, the external genital apparatus, according to Emery, is one of those most often involved. This is explained by anatomical considerations and by the vulnerability of the external genitalia in man to the lesions of venereal disease.

The principal anatomical considerations to be noted in connection with gangrenous processes of the scrotum are the laxity of the skin and subcutaneous tissues; the continuation of the dartos into the perineum and anterior abdominal wall, and its lateral attachment through Colles's fascia to the rami of the pubes and ischii; the large amount of loose areolar tissue beneath the dartos; the continuation of the three spermatic fasciæ into the groin; the free supply of blood from different sources with but few anastomoses between the arteries of the superficial and deep layers; and the abundance of large lymph spaces in the scrotum.

The greatest predisposing causes of gangrene of the scrotum are found in the laxity of the cellular tissue which

allows marked infiltration, and in the looseness of the skin which diminishes the resistance to inflammation. Other predisposing causes include those conditions which might result in œdema or infiltration of the scrotal tissues, such as nephritis, heart disease, certain conditions of the liver, or any interference with the free flow of urine from the bladder to the exterior; any systemic disease which lowers the vital resistance, such as Asiatic cholera, smallpox, diabetes, chronic alcoholism, etc. Edward Goodeve states that he has seen many cases of gangrene of the scrotum as a complication of Asiatic cholera among the natives of Bengal; and Marson says that "the scrotum is liable to become gangrenous after smallpox, especially in those suffering from gonorrhœa." Again, any wound, abrasion, eczematous patch of the scrotum or adjacent structures which might form an entrance of infection, is a predisposing cause. Age appears to play no part in the predisposition, cases having been reported varying in age from fourteen days to eighty years.

The exciting cause of gangrene of the scrotum may be anything which interferes with the nutrition of the part to such an extent that local death results. The rapidity with which gangrene occurs and the extent of the gangrenous process will be greatly modified by the condition of the nutrition of the part, the resistive powers of the patient, and the character of the exciting cause. The extent of the gangrene may vary from a spot the size of a dime to the entire scrotum and its contained organs, with extension into the perineum and the anterior abdominal wall. Usually, the testicle and its serous coats, the tunica vaginalis, are not seriously involved.

For the purpose of classifying cases of gangrene of the scrotum, it might be well to divide them into five groups according to exciting causes. Group I would then include those cases in which the gangrene was due to the action of bacteria either through "the specific chemical substance which they liberate or as the result of vascular obstruction due to the inflammatory process to which they give rise" (Warren). Group II would include those cases where there had been

interference with the nutrition of the part by obstructing the circulation, the causes being other than micro-organismal invasion, as in cases of non-inflammatory œdema and cases of infiltration of urine. Cases of gangrene caused by tight strapping of the testicle would also come under this group, although I have been unable to find any such cases reported. Group III would include those cases due to direct mechanical or chemical action upon the tissues. Group IV would include those cases caused by thermal agencies, heat or cold. And Group V might be called the neuropathic group, in which the gangrene is caused by injury of the so-called trophic nerves.

Group I would include by far the greatest number of cases of gangrene of the scrotum that have been reported. These might again be divided into three classes, viz., 1, those in which the invading organism is a streptococcus of great virulence which gives rise to the fulminating gangrene, or *gangrene foudroyante* of the French writers; 2, in which the streptococcus of erysipelas is predominant; and 3, in which the ordinary pyogenic micro-organisms are the invading bodies.

The first complete description of fulminating gangrene of the scrotum, according to Emery, who has written a very exhaustive treatise on the subject, was given by Fournier in 1883. Fournier cites three constant characteristics,—the sudden explosion of the phenomena in the midst of perfect health; rapid evolution of mortification; and the apparent total absence of any of the usual causes of gangrene. In 1894 Volterra gave a description of a remarkable case similar to Fournier's, accompanied by a report of a thorough bacteriological investigation. He concluded that the cause was a very virulent streptococcus. In 1896 Emery studied a case in which he confirmed the researches of Volterra.

The onset of fulminating gangrene is generally preceded by a vague uneasiness, heaviness, or dragging of the parts, at times by pain after micturition, or by a feeling of fulness in the perineum, the location of the initiatory symptom depending upon the point of invasion. This is followed very rapidly by

swelling of the scrotum and penis, or by a balanoposthitis and lymphangitis if the seat of the trouble be in the prepuce. The progress of the disease is so rapid that by the time the medical adviser sees the patient, there is redness of the scrotum and penis, with marked œdema. Here and there over the organs will be found purplish spots. The increase in size of the scrotum increases very rapidly, there is soon œdema of the perineum and anterior abdominal wall, with emphysematous crackling in all of the involved tissue. The parts become black, gangrene resulting either as a result of the poisons thrown off by the streptococci, or by the inflammatory interference with the circulation. The combative powers of Nature soon check the progress of the infection, a very distinct line of demarcation is formed, and the gangrenous portion sloughs away. The tunica vaginalis is exposed, covering the testicles which hang suspended by their cords. Granulations form rapidly, and the patient is usually restored to health with the functions of his procreative organs unimpaired.

Constitutionally, the symptoms from the beginning may be very slight,—a simple chill with rise of temperature, or there may be chills, sweats, headache, nausea, fever, and excessive thirst.

The first case I wish to report belongs to this class. C. T., aged thirty years, was kindly referred to me by Dr. W. H. H. Githens. The patient had gonorrhœa when nineteen; suppurating inguinal adenitis when twenty-one. For two or three years he was troubled by an eczematous patch on the scrotum, which at times caused intense itching. He arose on the morning of July 20 in perfect health, as far as he knew. About noon of that day he experienced a heavy sensation in the scrotum and felt sick, with headache and some nausea. At 3 P.M. he noticed that the scrotum was becoming enlarged. He retired. The swelling of the scrotum increased very rapidly, and by 6 P.M. was "as big as a hat," as he expressed it. He had considerable pain. Dr. Githens, who saw him the next morning, within twenty hours of the initial symptom, writes that "the patient was suffering from 'blood poisoning' consequent (most probably) upon

scratching himself with surgically dirty finger-nails. He had long suffered from eczema, and at that time had an eruption on the perineum and scrotum, and, according to his own account, was frequently relieving the local irritation by scratching with his finger-nails. I thought also of the possibility of fly-bites, but of that there is no proof. When I saw him first (July 21), the dorsum of the penis and the entire scrotum were black, crepitant on pressure, and offensive in odor. I ordered wet applications, and succeeded in soon stopping the sloughing process and getting lines of demarcation formed. There was no erysipelas. I did not note any increase of temperature."

I first saw the patient July 29, at which time he was very pale, pulse rapid, heart irritable. Temperature, 100.2° F. The penis and scrotum were greatly swollen. Most of the scrotum was gangrenous, and a portion of the skin of the penis was in a similar condition. There was marked bogginess in the perineum and the pubic region, with emphysematous crackling there and in the scrotum. The gangrenous portions were removed. They included all of the tissues down to the tunica vaginalis. A few sloughs were present on the tunica. There was sloughing of the superficial fascia of the anterior abdominal wall, which was removed in large pieces from below. The odor of the sloughing tissues was very offensive. The parts were bathed frequently with creolin solution and dressed with wet creolin dressings. Granulations soon appeared and grew rapidly. The spermatic cords retracted, drawing the testicles close to the external abdominal ring. After the granulations had covered the testicles, attempts were made to use the redundant prepuce for plastic work, but none of the stitches held, owing to the frequent erections which the patient had. Small skin grafts were then implanted on the granulation tissue and the parts were soon healed. With the exception of slight pulling on one side when he has an erection, the patient suffers no inconvenience at present from his trouble.

Erysipelas of the scrotum is not at all uncommon. The disease often spreads from adjacent parts, or may be primary in the scrotum. It has followed ritual circumcision, excoriation from dribbling urine, bites of insects, wounds, etc.; and Rush in 1804 reported a case in which the infection was made pos-

sible by the "patient putting a handful of 'polygonum persicaria,' instead of paper, to a common use, after going to stool."

In this form of infection, the skin of the scrotum becomes dusky red, followed rapidly by œdema. The scrotum assumes a smooth, shiny appearance. The inflammation extends rapidly to the perineum and the abdominal wall. There may be enormous swelling of the scrotum due to the accumulation of serum in the loose connective tissue it contains. In favorable cases the symptoms subside, and resolution takes place with very little, if any, destruction of tissue. In the unfavorable cases, the infiltration of the scrotal tissues is so extensive and so rapid that there is interference with the blood-supply, and death of the tissues results. The extent of the gangrene varies from small patches to the entire scrotum, with involvement of the subcutaneous tissues of the perineum and abdomen. A line of demarcation forms and the sloughs may be removed, leaving the tunica vaginalis exposed.

The constitutional symptoms are similar to those connected with erysipelas in other regions. There is generally rigor and rapid rise of temperature, with symptoms of an acute fever.

One of the earliest cases of gangrene of the scrotum reported belongs to this class. It was described by Leverett Hubbard, of New Haven, Connecticut, in a communication to the Medical Society of London in 1786. The patient was forty years of age. The first symptom was slight pain in the inguinal region, with a chill followed by high fever. Dr. Hubbard says, "I visited the patient and found him in a high fever; the scrotum and penis greatly tumefied, and of a livid color; I immediately opened a vein and took away seventeen ounces of blood, which was as buffy as is usual in a violent pleurisy, with very little serum; I ordered a fomentation of bitter herbs boiled in water, to which was added rum." The gangrenous portions were cut away, leaving the tunica vaginalis exposed. Dr. Hubbard's account of the reparative process is very descriptive. He says, "The perineum began

to granulate and to heal very fast, and caused an adhesion, or union, of the testicles from each extremity which now resembled a twin peach or apple; the spermatic cords suffered a great contraction, and the testicles adhered closely to the perineum, and cicatrized favorably."

The second case I wish to report belongs to this class. I am indebted to Dr. Fairfax Irwin, of the United States Marine Hospital Service, for the privilege of presenting it.

L. A., aged thirty years, was admitted to the United States Marine Hospital Service suffering from suppurating inguinal adenitis consequent upon chancroidal invasion. Incisions were made over the masses, the parts thoroughly curetted, and packed. The wounds suppurated freely, but granulations formed slowly. The patient's general condition was very poor. Six weeks after the operation he developed erysipelas, and was transferred to the Isolating House. The inflammation spread rapidly, involving the scrotum and penis. There was marked swelling of the scrotum, which had a dusky-red, glazed appearance. The inflammation of the penis subsided, but that of the scrotum persisted until death of the entire part ensued. The gangrenous portions were removed, leaving the tunica vaginalis exposed. Granulations soon grew rapidly, joining the testicles together. There was marked contraction of the spermatic cords, with elevation of the testicles. Final healing was hastened by skin-grafting, which was performed by Dr. Ross, who circumcised the patient, using the skin of the prepuce for grafts.

Invasion of the scrotal tissue by pyogenic micro-organisms generally results from some focus of suppuration in the adjacent structures, such as chancroids, a boil, etc., or from neglect of the principles of clean surgery when operating upon the scrotal tissues. The progress of the inflammation is much less rapid than in either of the previous classes. There is some redness of the skin with œdematous infiltration. The swelling generally does not take place rapidly, although ultimately it may be very great. In other respects it resembles the erysipelatous inflammation. There are few, if any, constitutional

symptoms, unless general sepsis supervenes. The extent of the sloughing varies greatly, being often superficial and not extending below the dartos.

A very early case of gangrene of the scrotum due to this cause, probably, was reported by Edward Luttrell before the Medical Society of London in 1779. The patient was a laborer, forty-three years of age, who was suffering "from indurated and greatly diseased testicle, which was judged to proceed from a venereal cause, having frequently had lues venera." The testicle was removed. Two weeks later the edges of the wound became inflamed, the inflammation spreading through the rest of the scrotum, which soon became gangrenous and sloughed off. The wound healed by granulation.

The literature contains reports of thirty-six cases that would be classed under Group I. Of these twenty-six recovered, eight died, and in two no result was noted.

Case II.—Emery, 1896.—Patient aged thirty-nine years. Always in good health. November 15 had balanoposthitis. Preputial œdema neglected. November 30, general malaise, chills, high fever, headache, nausea, sweats. In bed three days. Genital organs normal. December 3, dull pain in inguinal region radiating to scrotum, accompanied by notable swelling of the scrotum. Patient very feeble. Scrotum swollen to size of child's head. Œdema extended to prepuce, into peritoneum, into inguinal and hypogastric regions. Three large incisions. There was no stricture of the urethra, nor any communication between the urethra and the incisions in the scrotum. Patient developed abscesses in different regions. The entire scrotum sloughed, exposing the testicles. Granulation. Recovery. Bacteriological investigation showed the presence of cocci with bacilli of various kinds. The cocci were in chains. Rabbits, submitted to intravenous injections of cultures, died of streptococcic septicæmia.

Case III.—De Bonnieres de la Luzellerie, 1887.—Age of patient not given. In 1853 had a chancre. In 1864 had severe rheumatism with lumbago. In 1880 had chancre. Addicted to use of alcohol. Had considerable œdema of prepuce after coitus. Made application to prepuce, which was followed by a phlyctenular eruption, which soon involved the penis and scrotum. There was general malaise. Patient became yellow. Scrotum increased rapidly in size and became gangrenous. Skin of pubic region very much inflamed and painful. Patient died of general sepsis.

Case IV.—Lallemant, 1884.—Patient aged twenty-six years. Had been in perfect health. First noticed pain in penis followed by œdema, which rapidly extended to the scrotum. This increased rapidly in size, became gangrenous and sloughed, exposing the testicles. Granulation. Recovery.

Case V.—Erichsen, 1860.—Patient aged twenty-eight years. No pre-existing cause. Penis and scrotum suddenly became infected with erysipelas. Scrotum increased enormously in size, followed by gangrene and sloughing. Testicles exposed. Patient died from pyæmia.

Case VI.—W. J. Smith, 1873.—Cook, aged fifty-eight years. In poor condition, intemperate. Had had poor food. Erysipelas of scrotum, which became swollen, œdematous, and crepitant. Gangrene with sloughing of the skin and dartos. Testicles not exposed. Patient recovered.

Case VII.—F. Howard Marsh, 1865.—Patient aged forty-nine years. Intemperate. When first seen was greatly prostrated. Penis and scrotum seat of erysipelatous inflammation. Scrotum size of four-year-old child's head. Perineum not involved. Urethra normal. Scrotum incised. Patient died of asthenia.

Case VIII.—Percival Pott, 1808.—Patient forty years of age. Had a large hydrocele. After hard ride on horseback, the scrotum was "covered all over with an inflammation of the erysipelatous kind. Was much increased in size and painful to the touch." Incised and large quantity of serum liberated. Next day the whole scrotum was mortified. "All the tumefaction of the scrotum was gone, but it seemed one large eschar. On the next morning he died."

Case IX.—Alexander Marcy, Jr., 1884.—Child, two weeks old. Penis and scrotum œdematous and swollen, and had the appearance of rhus poisoning. Evaporating lotions applied. Next day much worse, scrotum enormously swollen. Numerous punctures made into scrotum. Next day scrotum was gangrenous. Sloughed, exposing the testicles. Granulations. Recovery.

Case X.—Liston, 1834.—Patient aged fifty-four years. Exposed to all weathers. One month before, scrotum had become red, painful, and swollen, followed by gangrene and sloughing. On admission to hospital, both testicles were exposed. Granulation. Recovery.

Case XI.—Liston, 1835.—Age not given. Abscess over knee. Cured. Short time after complained of pain in groin, followed by erysipelas, which extended over groin, thigh, and scrotum, which became very much swollen. Gangrene of scrotum. Results not given.

Case XII.—Liston, 1834.—Shoemaker, aged twenty-one years. Erysipelas of scrotum, which became greatly swollen and gangrenous. Free incisions made. Scrotum sloughed, exposing the testicles. Granulation. Recovery.

Case XIII.—F. Lawton, 1880.—Child, aged fourteen days. Erysipelas of scrotum and groin with great pain. Scrotum greatly swollen. Dusky patch on scrotum, which sloughed. Testicles not exposed. Granulation. Recovery.

Case XIV.—R. Jones, 1868.—Farmer, aged fifty-two years. Smarting sensation and soreness of anus and genitals. No pain. Scrotum and

perineum became red and œdematous from erysipelas. Gangrene followed. Patient died in thirty-six hours after onset.

Case XV.—Harrison and Gross, 1887.—Private, aged forty-one years. Fall on buttock. Fulness in perineum. Urethra normal. Anterior surface of scrotum seat of dark streak. Scrotum swollen, but not very tender. Scrotum incised. Temperature rose to 104.5° F. Scrotum sloughed, exposing testicles. Granulations and skin graft. Recovery.

Case XVI.—George L. Cooper, 1847.—Patient aged fifty-two years. Intemperate. Exposed to cold. Uneasiness about anus. Twenty-four hours later scrotum red and swollen, crackling. Soon became gangrenous. Perineum boggy. Scrotum sloughed, exposing the testicles. Granulation. Recovery.

Case XVII.—George L. Cooper, 1847.—Patient aged fifty-five years. "Uneasy about the anus." Perineum boggy, scrotum very large, œdematous, emphysematous. Gangrene supervened. Scrotum sloughed, exposing testicles. Granulation. Recovery.

Case XVIII.—Morrant Baker, 1886.—Patient aged twenty-six years. Six weeks before had suppurating inguinal adenitis, which was opened. Soon followed by sudden, severe pain in scrotum, followed by rapid swelling until it became very tense. Perineum not involved. Scrotum incised. Became gangrenous and sloughed, exposing testicles. Granulation. Recovery.

Case XIX.—Morrant Baker, 1886.—Cabinet-maker, aged twenty-six years. Abscess in groin, which was opened. Patient did well for six weeks, then had sudden pain in scrotum, which became swollen to the size of a cocoanut. Temperature, 103° F. Scrotum incised. Became gangrenous and sloughed, exposing testicles. Granulation. Recovery.

Case XX.—E. G. Carpenter, 1880.—Age not given. Had been on spree. Slept in gutter. Next morning scrotum swollen. Went home and applied domestic remedies. Scrotum increased in size, but doctor not called in for a week. Scrotum size of man's head, doughy feel, ashy hue. Deep incision made into scrotum. Line of demarcation formed; slough of entire scrotum, exposing testicles. Granulations. Recovery.

Case XXI.—J. J. Summerell, 1875.—Pauper, aged eighty years. Had attack of erysipelas affecting scrotum, which became a gangrenous mass. Scrotum sloughed, exposing the testicles. Granulation. Recovery.

Case XXII.—J. J. Summerell, 1875.—Patient aged sixty years. Similar to above.

Lancet, September 15, 1860.—Ironmonger, twenty-eight years of age. Temperate. Six years previously had gonorrhœa. No stricture. Small, hard swelling in perineum six or seven times during last six years. This time ruptured, foul discharge. Infection of perineum, extending rapidly to scrotum. Scrotum size of man's head. Free incisions into scrotum. Erysipelatous blush over abdomen. Gangrene of scrotum, with sloughing exposing both testicles. Penis œdematous, but did not slough. Abscess in groin. Death from pyæmia on twenty-third day.

Case XXIII.—George B. Swayze, 1870.—Child, aged two years and

seven months. Phlegmonous erysipelas of scrotum. Greatly distended, hard, and very painful. Free incisions. Did not urinate for three days. Scrotum gangrenous, with ulceration into urethra. Scrotum sloughed, exposing testicles. Granulation. Recovery.

Case XXIV.—Mr. Sympson, 1878.—Patient aged sixty years. Abrasion of scrotum by long walk. Redness, œdema, marked swelling of scrotum. Gangrene, with sloughing of scrotum exposing testicles. Granulation. Recovery.

Case XXV.—H. W. Hagenbach, 1882.—Patient aged forty-two years. Pain in perineum and testicles. Perineum hard and indurated. Erysipelas of perineum and scrotum. Scrotum became enormously swollen. Erysipelas of lower abdominal wall. Penis much swollen. Lower half of scrotum sloughed, exposing testicles. Granulations. Recovery.

Case XXVI.—Blyckaerts, in 1876, reported a case in which gangrene of the scrotum followed the presence of pediculosis pubis. It is probable that this was a case of infection due to scratching the parts. The patient recovered.

Case XXVII.—C. W. Allen, 1894.—Patient aged thirty-four years. Had had gonorrhœa eight years before. Chancroid, with suppurating inguinal adenitis, three months before. Was addicted to use of alcohol. Had dull pain in scrotum, followed by marked swelling, emphysema, gangrene, sloughing of entire scrotum. Testicles exposed. Recovered. Granulation. Supposed cause to be infection, as patient gave indefinite history of having a wound.

Case XXVIII.—Mr. Jessop, 1871.—Patient aged twenty-five years. Had right-sided hydrocele. Was tapped three days later, had gangrenous patch at point of tapping. Gangrene spread, involving the whole scrotum, which sloughed, exposing the testicles. Granulation. Recovery.

Case XXIX.—Mr. Jessop, 1871.—Patient aged seventy-one years. Hydrocele right side. Tapped. One week later gangrene of entire scrotum. Patient died from sepsis.

Case XXX.—J. J. Harris, 1881.—Patient aged thirty years. Had small boil on scrotum, which he pricked with a pin. Infection, œdema, swelling to size of man's hat. Tension so great, drops of serum exuded. Scrotum incised. Gangrene of entire scrotum, which sloughed, exposing both testicles. Granulation. Recovery.

Case XXXI.—Morrant Baker, 1885.—Patient sixty years old. Some swelling of scrotum, to which he applied an irritating lotion. Marked swelling of scrotum in twenty-four hours. Gangrene, slough of entire scrotum, testicles exposed. Death from sepsis.

Case XXXII.—R. Liston, 1839.—Patient aged thirty-three years. Had an abscess near verge of anus. Opened. Two days later swelling of perineum and scrotum. Scrotum much distended, red, and shiny. Free incisions. Slough of scrotum. Result not noted.

Case XXXIII.—Samuel K. Brenner, 1895.—Patient eight weeks old. Breast-fed. No syphilis, tuberculosis, or rheumatism in parents. Temperature, 105° F. Swelling in right side of scrotum, from which

thirty cubic centimetres of pus was withdrawn by aspiration. Sac then incised and drained. Infection of scrotal tissues, sloughing. Patient died on third day. *Post-mortem.*—Serous covering of testicle and scrotal walls thick and injected. Thin layer of fibrin. Testicle and epididymis normal. Seropurulent collection in peritoneal cavity.

Case XXXIV.—C. D. Spivak, 1895.—Patient two years old. No hereditary history. Had varicella. Two days after eruption on face, scrotum became swollen and gangrenous. Three days later, penis, scrotum, and left inguinal region all swollen and very tender. Muddy crusts on left side of scrotum. Slough removed, left testicle exposed. Pus found in inguinal region. Granulation. Recovery.

Case XXXV.—W. H. Pollard, 1863.—Patient aged twenty-seven years. Strumous. Abscess in perineum. Infection and swelling of scrotum. Marked tension. Urethra normal. Gangrene of lower portion of scrotum. Penis gangrenous on dorsum. Scrotum sloughed, exposing testicles. Granulation. Recovery.

Case XXXVI.—George Wm. Pollard, 1875.—Patient aged fifty-three years. Had small boil on right side of scrotum. Scrotum swollen and painful. Incision of boil. Gangrenous spot appeared below the boil, spreading until the whole scrotum was involved. Scrotum sloughed, exposing testicles. Granulation and skin grafting. Recovery.

Group II would include those cases of gangrene due to non-inflammatory œdema and extravasation of urine. The cause of death in the former is due generally to interference with the nutrition of the part; in the latter there is added to this the marked irritating qualities of the urine when brought in contact with the tissues.

Non-inflammatory œdema of the scrotum is generally the result of renal or cardiac disease, or of inguinal or pelvic tumors. There is generally noted a uniform swelling of the scrotum which begins at the most dependent portion. The whole scrotum soon becomes involved. It is then doughy and inelastic and pits on pressure. There is no pain. The skin is semitransparent, becoming smooth and glossy, the rugæ disappearing with the increase of the œdema. The swelling is usually bilateral, although Percival Pott has reported one case in which there was one-sided non-inflammatory œdema which he diagnosed hydrocele. This was a patient forty-five years of age which Mr. Pott reported in 1808. He tapped the supposed hydrocele, but withdrew very little fluid. He

then recognized the true condition, and made a true incision into the scrotum. He says that "in three days the whole scrotum and skin of the penis were completely mortified and a considerable part of the pubes altered and eviscerated. In about three weeks the whole scrotum, the integument of the penis, and some part of the pubes cast off, leaving the corpora cavernosa and the tunica vaginalis as clean as if they had been dissected. The man got well." Mr. Pott also reported other cases which he called acute anasarca of the scrotum. He strongly advised against free incisions, after he had had some experience with these conditions, claiming that there was always sloughing of the tissues after incisions, but never after puncturing. Dr. Agnew also taught not to incise in these conditions, and never even to puncture unless the distention of the parts became so great as to threaten their vitality.

Extravasation of urine greatly resembles the acute inflammatory œdema, or erysipelas, of the scrotum in its progress. There is generally, however, a history of a neglected stricture, retention of urine, traumatism preceding the extravasation, or possibly a hard lump in the perineum. The trouble is generally first noticed in the perineum, where there is some swelling and bogginess, with pain and interference with micturition. A catheter should always be passed to aid in making a diagnosis. After the urine has invaded the periurethral tissues, there is rapid infiltration of the perineum, scrotum, penis, and pubic region. The urine acts as a violent irritant, inducing intense inflammation, which is usually followed by suppuration and sloughing. There is systemic effect, with chills, fever, thirst, great prostration, and delirium. Death usually results from septicæmia or uræmia, unless very early operative interference is instituted. This consists in free incision wherever there is infiltration, with drainage of the bladder, usually through the perineum.

The third case I wish to report comes under this group. W. G., aged twenty-seven years, was admitted to the German Hospital under the care of Dr. Deaver, to whom I am indebted

for the privilege of reporting the case. There was a history of the patient having had a stricture of the urethra, with several attacks of retention of urine. He was profoundly septic and delirious. Temperature, 104° F. The perineum, scrotum, and anterior abdominal wall were extensively infiltrated. The scrotum was ecchymotic from attempts, which had been made prior to admission, to reduce a supposed strangulated hernia. It was impossible to pass a catheter. An external urethrotomy was performed, with permanent drainage of the bladder. Free incisions were made into the scrotum and anterior abdominal wall. The superficial fascia of the abdominal wall was gangrenous, forming an immense slough, which was subsequently removed. The entire scrotum sloughed, exposing the tunica vaginalis with the testicles suspended by the spermatic cords. There was no sloughing of the skin of the penis. The testicles were covered by granulation tissue. The patient left the hospital seventy-two days after admission. He experienced nocturnal emissions before leaving the hospital.

The literature contains reports of fifteen cases that would belong to this group, of which eleven recovered and four died.

Group II., Case II.—William Corless, 1853.—Patient thirty-eight years of age. Had retention of urine from old stricture. Rupture of urethra with extravasation of urine, resulting in gangrene and sloughing of scrotum. Testicles exposed. Granulation. Recovery.

Case III.—Morrant Baker, 1885.—Patient aged fifty-four years. Had had retention of urine two weeks before. Perineum swollen and painful. Skin of scrotum and penis gangrenous. Free incisions made. Patient died.

Case IV.—Thomas Bain Whitton, 1888.—Patient aged forty-eight years. Never had had any trouble with urinary organs. Went on spree, and slept in wet clothes. In morning could not pass urine. Had retention. Rupture of urethra with extravasation of urine. Swelling of perineum, scrotum, and penis. Free incisions made. Gangrene of scrotum with sloughing, exposing testicles. Granulation. Recovery.

Case V.—William A. Byrd, 1876.—Age not given. Retention of urine. Small gangrenous spot in perineum. Scrotum then involved. Free incisions. Gangrene of scrotum with sloughing, testicles being exposed. Two inches of rectum were exposed. Granulation. Recovery.

Case VI.—D. H. Dickinson, 1879.—Patient thirty-five years of age. First seen with extravasation of urine. Temperature, 105° F.; pulse, 130. Scrotum size of cocoanut, black, with abscess in right inguinal region.

Free incisions allowed escape of urinous fluid. Gangrene, with sloughing of entire scrotum. Testicles exposed. Granulation, Recovery.

Case VII.—F. Howard Marsh, 1865.—Patient forty-five years of age. Intemperate. Had had stricture many years. Pain and swelling in perineum several days. Scrotum six inches in diameter, tense, pallid, glossy, œdematous. Œdema extended as high as umbilicus. Free incisions into perineum and scrotum. Gangrene. Slough of scrotum, groin on both sides. Patient died in five weeks from uræmia.

Case VIII.—W. A. Lightbourne, 1888.—Patient aged twenty-nine years. Working in bush felling trees. Sudden violent pain in right groin and testicle. Three days no medical attention. Fourth day, temperature, 96.5° F. Elongated swelling in right groin, extending into scrotum. Scrotum swollen half-way to knee. Gangrene of skin of scrotum and of groin. Testicles not exposed. Granulation. Recovery.

Case IX.—W. L. Wharton, 1843.—Carpenter, aged thirty-one years. Had connection with squaw during menstrual flow. Phimosis, with obstruction to flow of urine. Great distention of penis and scrotum, almost prevent walking. Scrotum punctured. Gangrene, with sloughing of parts of prepuce, entire scrotum, integument of right inguinal region. Testicles exposed. Ulceration into urethra posterior to glans. Granulation. Recovery.

Case X.—William Auchincloss, 1829.—Patient eighteen months old. Had retention of urine, ulceration into urethra. Died. *Post-mortem.*—Abscess of kidney, ureters distended to three times size of crow-quill. Bladder studded with fungous tumors.

Case XI.—Perry Dickens, 1853.—Butcher, sixty-four years of age. Had retention from hypertrophied prostate. Pain and fulness in perineum. Became inflamed, extending to scrotum, which became enormously swollen. Gangrene of scrotum and perineum. Free incisions, liberating fœtid gas and fluid. Slough of scrotum exposing testicles. Granulation. Recovery.

Case XII.—Christopher Fleming, 1858.—Laborer, forty-five years of age. Had had difficulty in urination, with swelling of penis and scrotum for four years. Had general anasarca. Fulness in perineum, extending to scrotum, which became hard, swollen, tense, and painful Erysipelas of scrotum and penis. Free incisions. Gangrene with sloughing of scrotum. Testicles exposed. Granulation. Recovery. Case of general anasarca with erysipelas.

Case XIII.—Percival Pott, 1808.—Patient aged fifty-eight years Was "afflicted with an anasarcous tumor of the belly, legs, thighs, scrotum, and penis. He had taken many medicines and more than one quack remedy since being in London." The swelling in penis and scrotum became so great that he could not wear trousers. Incisions made on each side of scrotum. Edges of incisions became hard and inflamed, with marked pain. Followed by a "kind of emphysematous tumescence." Nine days later the "whole bag was in a state of mortification." Scrotum sloughed, exposing both testicles. Granulation. Recovery.

Case XIV.—Percival Pott, 1808.—Patient forty years of age. Had

drinker. "His legs, thighs, scrotum, and penis were loaded with a watery tumor." Incisions made into scrotum. Wounds became inflamed, swollen, and very painful. "The whole scrotum and skin of the penis became black and mortified, as did also the part of the pubes." Patient died on the eleventh day.

Case XV.—American Medical Weekly, 1876.—Patient forty years of age. General acute anasarca. Had had intermittent fever. Scrotum size of crown of hat. Scrotum punctured. Gangrene followed. Slough of entire scrotum with testicles exposed. Granulation. Recovery.

Group III would include those cases due to direct mechanical or chemical action upon the tissues. There is traumatism or the action of some powerful escharotic which acts here as elsewhere in the body, with the exception that the destruction of tissue is more rapid and more extensive. In traumatic cases, the gangrene may be due to the rupture of blood-vessels supplying the part, or to the consequences of infection which take place at the time the traumatism is inflicted.

Baurienne, in 1764, reported a case in which a boy of fourteen had been gored by an ox. Four days later he was admitted to the hospital with an enormously swollen scrotum, which was very painful, œdematous, and shiny. Death of the part had commenced. Free incisions were made into the scrotum, but it soon sloughed, exposing the tunica vaginalis. The patient recovered, the testicles being covered by granulations.

An interesting case was reported by Mr. Hagan in 1877, in which the patient, who was thirty years of age, was inconvenienced by the unusual length of his scrotum, which reached half-way to the knees. The lower third was amputated. This was followed almost immediately by swelling of the remainder of the scrotum, which in six hours reached an enormous size. The pain was intense. Gangrene supervened, with sloughing of the scrotum to within an inch of the pubes. The patient recovered.

Galloupe and Graves reported a case in 1876 in which the scrotum of a man twenty-one years of age was almost completely torn off by machinery. Strange to relate, the testicles and spermatic cords were not injured. The scrotum was replaced, but soon became gangrenous and sloughed. The patient recovered.

The literature contains the reports of thirteen cases which would belong to this group. Of these seven recovered and six died.

Group III, Case IV.—James B. Burnett, 1869.—Patient fifty years of age. Fell twenty feet, struck on nates. Scrotum and perineum soon became swollen and gangrenous. The body from the pelvis to the sternum was emphysematous. Free incisions made. Patient died from asthenia. *Post-mortem.*—Superficial fascia from pelvis to umbilicus was gangrenous. Bladder and urethra dissected out and found to be normal. Scrotum contused. Supposed that there was an extravasation of blood which decomposed. No signs of uræmia.

Case V.—Liston, 1834.—Patient forty years of age. Kicked in perineum. No trouble for eight days. Then pain and swelling of scrotum, with emphysematous crackling. Free incisions. Cellular tissues were gangrenous. Patient died before sloughs had separated.

Case VI.—William Auchincloss, 1829.—Patient thirty-seven years of age. Had a large right-sided hydrocele. Probably contused. Small patch of gangrene, which rapidly invaded the whole scrotum. Urethra normal. Patient died of sepsis.

Case VII.—J. B. Shapleigh, 1882.—Patient forty years of age. Fell on joist. Inflammation, œdema, discoloration of the perineum and scrotum. Retention of urine. Attempt to puncture bladder through rectum failed. Suprapubic drainage of bladder. Gangrene of scrotum, with sloughing. Testicles exposed. Rupture of urethra by fall. Granulation. Recovery.

Case VIII.—Shapleigh.—Patient fifty-four years of age. Had had stricture of urethra. Fell on barrel, striking perineum. Rupture of urethra with extravasation. Swelling of scrotum, which became gangrenous. Sloughing of scrotum. Patient developed an acute diarrhœa and died.

Case IX.—Stephen Smith, 1851.—Laborer, aged fifty-one years. Intemperate. Struck testicle. In three days the scrotum was very painful. Not red, not tense. Became inflamed, followed by gangrene and sloughing. Testicles exposed. Developed erysipelas and died.

Case X.—W. F. Stevenson, 1883.—Patient forty-five years of age. Scrotum and penis swollen and gangrenous when first seen. Swelling in perineum. Patient voided urine free from blood. Redness of abdominal wall. Penis, scrotum, and perineum incised. Collapse. Patient died fifty-four hours after receiving an injury, having been struck by a tent-pole. *Post-mortem.*—All organs healthy. Urethra patulous. Body of penis infiltrated with dark blood. Small ecchymotic patch towards outer end of urethra.

Case XI.—A. Grainger Bisset, 1904.—Age not given. Scraping contusion of scrotum which caused shock. Unable to work. Retired. Had rigors, with fever. Unable to take food. Sharp and severe pain in lower part of abdomen. Much pain in scrotum. Urinated freely. Temperature, 103° F. General appearance one of collapse. Whole scrotum swollen and tense, size of a cocoanut. Penis not affected. Gangrene of scrotum. Gangrenous portions removed. Testicles exposed. Plastic operation by means of flaps from thighs. Recovery.

CASE XII.—THOMAS M. CULLEY, 1876.—Age not given. Patient thrown against saddle while riding. Marked inflammation of scrotum, with enormous swelling. Gangrene. Sloughing. Testicles exposed. Granulation. Recovery.

CASE XIII.—ROSENBERGER, 1885.—Patient twenty-six years of age. Injured the penis by striking against the pubic bone of his wife. Marked swelling immediately of the penis, extending to the scrotum. Urine withdrawn by catheter. Swelling of the scrotum became very great. Gangrene of scrotum followed by sloughing. Testicles exposed. Plastic operation by taking flap from thigh. Recovery.

Group IV would include those cases caused by thermal agencies, heat or cold. There have been three cases reported in which exposure to cold was the cause of gangrene of the scrotum. Curling and Sir Astley Cooper have each reported one, and D'Alvigny makes mention of a third which came under his notice in 1853. The patient, thirty years of age, was frost-bitten on the scrotum. He exposed the part to the heat of a large fire. Two days later the scrotum was so large "that its bursting was apprehended at every moment. There was intense pain. Gangrene supervened and the entire scrotum sloughed, exposing the tunica vaginalis." The patient recovered.

Group V would include the neuropathic cases in which injury to the so-called trophic nerves is the cause of the death of the part. Platt, Winslow, and William J. Jones have reported cases in which operations had been performed for the removal of enlarged inguinal glands. In their cases, gangrenous patches of the scrotum appeared at intervals varying from two to ten days after the operation. In arriving at the cause of the gangrene, Platt considered erysipelas, which was not present; gravitation of septic fluids or direct extension from the groin to the scrotum, which was not admitted; interference with the circulation by obstructing the free flow of blood to or from the part. There was no such obstruction. He therefore concluded that the cause was "probably an acute reflex trophic lesion due to irritation of the branches of the ilio-inguinal nerve of the groin, reflected to the terminal filaments in the scrotal tissues."

The gangrene occurs in patches, spreading to the greater part of the scrotum in some cases. In some instances the sloughing is superficial, not extending below the dartos.

The literature contains six cases that would belong to this group. Of these five recovered and one died.

GROUP V, CASE I.—RANDOLPH WINSLOW and W. J. JONES, 1886.—Patient forty years of age. Had chronic inguinal adenitis, which suppurated. Whole mass dissected out. Wound loosely approximated and dressed with carbolic acid and oakum. Wound all right for one week. Then lost its healthy appearance. Scrotum became œdematous, followed by gangrene of lower third of sac. Patient died three weeks after operation from pyæmia.

CASE II.—WINSLOW and JONES.—Patient forty years of age. Chronic inguinal adenitis. Mass excised. For four days all went well. Then the scrotum became œdematous and finally gangrenous. Patient recovered.

CASE III.—WINSLOW and JONES.—Patient thirty years of age. Inguinal adenitis dissected out. Wound healthy for ten days. Then œdema of scrotum began, followed by gangrene, with sloughing of two-thirds. An abscess developed in Scarpa's triangle. Patient recovered.

CASE IV.—W. B. PLATT, 1885.—Male, aged forty years. Inguinal adenitis of two years' standing. No suppuration. Syphilis denied. Glands were excised, wound being closed except at lower end, where drainage was introduced. On second day after operation, left side of scrotum became red and swollen. Gangrenous patch formed on scrotum, measuring one and one-half by two inches. This sloughed and healed by granulation. The testicles were not exposed. Patient recovered.

CASE V.—PLATT.—Age not given. Suppurating inguinal adenitis. Mass curetted. In a few days the bottom of the scrotum was red, swollen, and tender. Two patches of gangrene formed, separated by skin, but connected subcutaneously. Testicles not exposed. Wounds healed by granulation. Recovery.

CASE VI.—PLATT.—Age not given. Inguinal glands curetted. Had gangrenous patch four inches square on bottom of scrotum, which sloughed. Healed by granulation. Recovery.

Several cases of gangrene of the scrotum have been reported in which no cause for the trouble was assigned.

ISAAC OTT, 1873.—Patient sixty-six years of age. First seen with small red spot on lower surface of prepuce. Inflammation extended rapidly, involving the penis and scrotum. Scrotum size of pig's bladder. Gangrene of scrotum, with purplish spots over abdomen. Patient died same day. No cause stated.

Two days after onset of trouble, the wife of patient used husband's commode. Had not copulated for some time previously. Three days later wife had purplish inflammation of vulva, extending over abdomen. Vulva much enlarged. Patient died four days later. Cause not given. Probably erysipelas.

C. M. Ford, 1870.—Seaman, twenty-eight years of age. Burning in scrotum. Scrotum dark brown, cellular tissue filled with serous fluid. Three incisions. Gangrene of the whole scrotum with sloughing. Testicles exposed. Granulation. Recovery. No cause stated.

Robert Paley, 1839.—Had seen one case twenty-five years before. Patient thirty years of age, very regular in habits. Uneasiness in scrotum. Soon became swollen and inflamed. A dozen leeches were applied, followed by fomentations and purgatives. Scrotum became gangrenous. The scrotum, prepuce, and greater part of the skin of the penis sloughed. Patient recovered. No mention made of covering of testicles.

Robert Paley.—Second case. Farmer, thirty-five years of age. Itching of penis and scrotum. Both became swollen and inflamed. Blood drawn, and fomentations applied. Gangrene of scrotum, inflammation extending as high as the umbilicus. Scrotum sloughed. Patient recovered. No mention made of covering of testicles.

Paley calls attention to the following: The surgeon in charge of the first case had six cases of puerperal sepsis while treating the scrotal case. The surgeon in charge of second case had a patient with puerperal sepsis, and was advised to leave his practice for a few weeks. Paley says, "There is not the slightest doubt on my mind that the surgeon who was in attendance was the means of communicating something (call it what you please) from the patient laboring under the disease of the scrotum to the lying-women, which in them produced puerperal fever."

Mr. Paget, 1865.—Carman, aged forty-six years. Admitted to hospital in collapse. Scrotum and penis were swollen, the former being dull green and very œdematous. Large catheter passed. Scrotum incised. Patient died in a few hours.

Post-mortem.—Normal organs and urethra. Had been intemperate. No cause could be found for the condition. Probably result of depressed condition of system.

J. M. Smook, 1874.—Laborer, aged fifty-four years. Had slight but constant pain in penis, scrotum, and inguinal regions. Blister appeared on penis. Scrotum and penis became greatly enlarged and emphysematous. Gangrene with sloughing. Testicles exposed. Patient died of asthenia. No cause given.

Lapaume, 1876.—Patient forty-two years of age. In good health. While riding felt pain in penis, followed by œdema of prepuce, which extended into scrotum. Scrotum became gangrenous and sloughed, exposing both testicles. No result stated. No cause given.

A. de Castro Jobin, 1885.—Patient aged twenty years. Suffered from double suppurating inguinal adenitis. Marked pain in penis and scrotum, both of which became enormously enlarged. Scrotum became gangrenous, followed by sloughing. Testicles exposed. Granulation. Recovery.

Lallemant.—Patient aged forty-nine years. Pains in penis and scrotum followed by marked swelling of both organs and by gangrene of the scrotum. Patient died. Cause not stated.

E. E. Kelly, 1894.—Patient thirty-four years of age. No venereal disease. Swelling of prepuce, then penis and scrotum. Slight itching and dull pain. Temperature, 103° F. Scrotum gangrenous and sloughed. Testicles exposed. Granulation. Recovery. No cause stated.

The symptoms of the conditions preceding gangrene of the scrotum vary, as shown, with the exciting cause.

The prognosis in these cases should always be guarded. Of ninety-three cases, including those reported this evening, seventy recovered and twenty-three died, a mortality in all cases of 23.5 per cent. The testicles almost invariably retain their functions, if the patient recover.

The most effective treatment is prophylactic. All conditions which interfere with the free flow of urine from the bladder should be corrected as early as possible. All wounds that might form an entrance for micro-organisms should be treated under the strictest principles of clean surgery. After swelling of the scrotal tissues has commenced, free incisions should be made in all cases except those of non-inflammatory œdema. In the latter cases attention should be directed to the underlying cause of the œdema. The incision should always extend through the skin and dartos, thus reaching the loose areolar tissue beneath in which much of the infiltration takes place. After gangrene has supervened, the gangrenous portions should be removed and the exposed structures treated according to the principles of clean surgery, special attention being paid to any recesses in which pus might collect.

The testicles will be covered by granulation tissue which will form a sufficiently useful scrotum. A larger scrotum may

be formed by a plastic operation. Bissett reports a case in which a plastic operation was performed by Mr. Parry. An elliptical flap was dissected from the inner aspect of each thigh. These were united by horse-hair sutures above the testicles and to the remnants of the scrotum. Three weeks later the pedicles of the flaps were divided and brought together below the testicles. The result was perfect.

Lente reports one case in which the surgeon did not know what to do with the testicles, and so performed double castration. This should never be done, except in cases where the gangrenous process has destroyed the organ. Even when this is suspected, it is better to wait until Nature throws off the sloughing portions before sacrificing the entire testicle.

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Dr. John B. Deaver said his experience has been limited to cases of gangrene of the scrotum due to extravasation of urine; he has never seen a case not due to this cause. They are quite common at the Philadelphia Hospital, where cases of obstruction of urine, and consequently extravasation, are numerous.

MULBERRY VESICAL CALCULUS.

Dr. Addinell Hewson showed a mulberry vesical calculus, together with the bladder, prostate, and penis of the subject from whom it was removed. The man was an Irishman of eighty-three years, an unmarried, illiterate laborer, and a moderate drinker. He died in a poor-house, but had complained of no symptoms whatever referable to the stone. The bladder was found thickened and ribbed, and partially embedded in the wall was the typical mulberry calculus shown. The bladder wall was also the site of two cysts. One was situated in front just above the pubis and was the size of an egg; the second was behind the prostate gland. That organ was enlarged and very firm and dense, but the middle lobe was almost free from involvement. Evidently there was but little interference with urination.

CHRONIC DUODENAL ULCER; GASTROJEJUNOSTOMY.

Dr. De Forest Willard presented a specimen removed from a man, thirty-eight years of age, who entered Dr. Musser's Service, Medical Ward, Presbyterian Hospital, on account of hæmorrhage from the bowels which had lasted for three weeks. Seven months previous he had an attack of severe pain in right upper quadrant of abdomen. He was in bed two weeks; since then has had frequent but less severe attacks of same pain, and had noticed that his stools had a tarry appearance. Present attack began three weeks before admission, with sharp pain in epigastrium radiating along right costal margin to lumbar region. Nausea, gaseous distention, retching several hours after taking food, with vomiting of small quantities of material which he described as resembling tobacco juice. Appetite poor. Emaciated; extremely pallid; red blood-corpuscles, 2,500,000; hæmoglobin, 23 per cent.; stools contain blood. Examination of gastric contents showed hyperacidity, hypersecretion, and retention; no blood. Stools showed blood. Urine negative. Physical examination, tenderness to right of epigastrium. No tumor.

Diagnosis, duodenal or gastric ulcer near pylorus; possible gall-duct obstruction. Operation following day. Median incision. Hard mass with duodenum, gall-bladder, pancreas and pylorus condensed and adherent. No signs of peritonitis. Removal impossible; anterior gastrojejunostomy with Murphy button. Patient was so profoundly anæmic, hæmoglobin 23 per cent., that additional suture of the two limbs of the bowel could not be done. Operation apparently had no effect, good or bad, and he died from exhaustion three days later with continued bleeding.

Post-mortem.—No evidences of peritonitis; no leakage from gastro-enterostomy; all stitches tight and in good position. Large duodenal ulcer just beyond the pylorus, which had perforated entirely through the coats of the bowel; but before perforation, the gall-bladder had become thoroughly adherent, so that no escape had occurred into the peritoneal cavity. This inflammatory process had thickened and condensed the gall-bladder and its ducts, so that its wall was a third of an inch in thickness and it was entirely empty. The lumen of the button was filled with soft coagula, but no leakage had occurred at the stitches.

Dr. W. W. Keen asked if examination of the blood had been made after the operation. The hæmoglobin before operation was 23 per cent., below the limit of safety as placed by von Mikulicz. Death apparently was not connected with the anæsthetic, and a blood count might have thrown further light upon the matter. The anæsthetic would reduce the hæmoglobin to some extent.

Dr. E. B. Hodge, who exhibited the specimens for Dr. Willard, said no blood examination had been made after operation. Small quantities of blood were passed by the mouth and by the bowel, but the patient was more comfortable for a day or two. He then gradually failed, and died of exhaustion sixty hours after operation.

SENILE ATROPHY OF CRANIAL BONES.

Dr. De Forest Willard presented the skull of a man, seventy years of age, who, after a fall down-stairs, became totally unconscious, with stertor, and slow pulse. Operation without ether, and with no signs of pain. Entire left side of skull found broken into a dozen pieces, brain crushed, and oozing from openings in dura.

This great destruction was due to the extreme thinness of the cranium, which in many places was infantile in thickness and exceedingly fragile. Many fragments, an inch square, were removed, but patient never recovered consciousness. With a skull so atrophied, a very slight injury would have caused a fracture.

AN EXPERIMENTAL AND HISTOLOGICAL STUDY OF CARGILE MEMBRANE.

WITH REFERENCE TO (1) ITS EFFICACY IN PREVENTING ADHESIONS IN THE ABDOMINAL AND CRANIAL CAVITIES AND AROUND NERVES AND TENDONS, AND (2) ITS ULTIMATE FATE IN THE TISSUES.

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EXPERIMENTAL STUDY BY DR. CRAIG.

It is not worth while to attempt an enumeration of the efforts which have been made to prevent adhesions in the peritoneal cavity; nor is it necessary to lay stress upon the necessity for preventing such adhesions when it can be accomplished. Adhesions within this cavity are, on the whole, beneficial, however harmful under certain circumstances. We cannot expect Nature to differentiate; it is left to the devices of the surgeon to prevent, if he can, adhesions when they would be harmful, and, in truth, it may be stated that he has succeeded but poorly.

In May, 1902 (*Medical Record*, May 17, 1902), Dr. Robert T. Morris, of New York, published the results of a series of experiments carried out upon rabbits, to determine the value of a specially prepared animal membrane derived from the peritoneum of the ox. The effort was made to prevent adhesions within the peritoneal cavity. Attention was first called to this membrane by Dr. Charles Cargile, of Bentonville, Arkansas, who sent Dr. Morris specimens of the membrane to be used, hence the New York surgeon termed the material Cargile membrane, an eponym which has since become common. The membrane is not essentially different from goldbeaters' skin, except in the method of its preparation. As prepared by Johnson and Johnson, it comes in small sheets about eight by sixteen centimetres in size, and is treated after a special method. Some of it is treated evidently somewhat after the manner of chromicized catgut, and is hence termed chromicized Cargile membrane; another preparation is unchromicized. The report of Dr. Morris, on the whole, was favorable, and he appeared to believe that the membrane possessed distinct advantages in preventing adhesions. His conclusions, somewhat abridged, were as follows: Cargile membrane seems to resist absorption in the peritoneal cavity for more than ten days and less than thirty days. Its presence apparently causes the formation of temporary loose adhesions, which are harmless, and which become absorbed for the most part in less than thirty days. The membrane seems to cause very little disturbance to the peritoneum; it does not furnish a good culture medium for bacteria, and it protects areas of peritoneal surface that have suffered injury to their endothelial covering, until new endothelial cells have repaired the injury without involving the neighboring peritoneum. It is not necessary to suture the membrane in place, as it becomes instantly adherent to moist surfaces, and is not readily dislodged afterwards.

If the membrane possessed the merits which Dr. Morris's experiments seemed to warrant, I could not understand why surgeons did not make more general use of it as a protective covering for surfaces denuded of peritoneum, and in other situations in which it would appear applicable.

To satisfy myself of the value, or the reverse, of this membrane, in the summer of 1904 I undertook a series of experiments in the laboratories of the Jefferson Medical Col-

[1] The death of Dr. Craig, March 14, 1905, from cerebrospinal meningitis, contracted while in attendance upon a patient suffering from that disease, lends additional interest to this report of his latest study.

lege Hospital. The membrane was kindly furnished me by the manufacturers above mentioned. Dogs were used in the experiments, and not only were tests made in the peritoneal cavity, but likewise in the protection of tendons and nerves, and the cranial cavity was invaded. After various intervals of time the seat of operation was exposed in each case, the clinical conditions ascertained, and, in a number of instances, specimens of tissue which had been in contact with the membrane were submitted to Dr. Ellis, associate in pathology at the College, who kindly undertook the microscopic investigations in this research. His findings are set forth in a separate portion of this paper.

It will be noted in the following recitation of the experiments, that when Cargile membrane was used in the peritoneal cavity of a dog, in most instances the membrane was anchored in place by fine silk sutures. It was of course recognized that the irritation produced by the sutures would, in a measure, vitiate the experiment; but it was believed, and subsequent experiments showed the assumption warranted, that if a sufficiently large piece of membrane were used, so that the sutures could be placed on either side of the intestine well towards the mesenteric attachment, the irritation produced by them need not interfere with the surface opposite that attachment. Furthermore, it was found by simple tests that the statement of Dr. Morris, namely, that the membrane would adhere readily and sufficiently to a denuded surface without suturing, was correct so long as the peritoneal, or denuded surface, was dry, or relatively so; but directly the intestine with the attached membrane was returned to the peritoneal cavity and bathed for a short time in the peritoneal fluid, the membrane ceased to adhere and readily slipped from the particular point covered. With this fact, repeatedly demonstrated, in mind, we of course could not expect that the membrane would adhere and remain where placed, despite the various movements of the animal and the peristaltic activity of the abdominal viscera. I therefore anchored the membrane by sutures, to be sure that it remained *in situ* over the denuded

area. It is conceivable that Cargile membrane may be placed in the pelvis or similar situations, between the peritoneum and a denuded surface, or between denuded surfaces, and remain in place without being anchored. It certainly will not remain, when unanchored, on either visceral or parietal surfaces when these are bathed in fluids and subjected to friction, be it never so little, from peristaltic activity. I may state in passing that I tried anchoring by means of celloidin and also by means of formalin-gelatin. Neither was a success.

All the dogs operated upon were profoundly anæsthetized with ether and treated according to the rules of aseptic surgery, so far as could be conveniently carried out. In only one instance did peritonitis occur, and this was from a defective end-to-end anastomosis.

Experiment No. I.—The abdominal cavity of a dog having been opened, a loop of intestine near the stomach was lifted out and two surfaces opposite the mesenteric attachment, each one and one-half centimetres square, were denuded of peritoneum, sponged until dry, covered with separate pieces of unchromicized Cargile membrane without anchoring, the abdominal wound being closed with silkworm-gut sutures. Twelve days later the abdomen was reopened and a mass of omentum was fairly firmly adherent to the distal denuded surface, and both omentum and liver were adherent to the proximal denuded surface; no Cargile membrane was found; either it did not remain *in situ*, or it had been absorbed and adhesions formed subsequently.

Experiment No. II.—The abdomen of a dog was opened and a loop of small intestine was brought out. A surface one centimetre by one and one-half centimetres was denuded of peritoneum and covered with chromicized membrane, the piece being large enough to extend back on either side to the mesenteric attachment, where it was anchored by sutures. Ten centimetres distal to this was anchored in like manner a piece of unchromicized membrane over an undenuded surface; further distal by ten centimetres was anchored similarly, a piece of chromicized membrane over a denuded surface; while still distal to this was anchored a sheet of chromicized membrane over an undenuded surface. In this experiment I sought to compare the effects of placing chromicized and unchromicized membrane each on denuded and undenuded surfaces. The sutures were so placed that I could identify the several pieces. Fourteen days later, forty centimetres of the bowel containing the four separate experiments were resected, examined macroscopically, and submitted to Dr. Ellis for microscopic examination. It was of interest to note that while a mass of adherent omentum completely covered the site of opera-

tion in each case, and a loop of bowel was adherent in two places, yet the Cargile membrane was at no place completely absorbed; both the chromicized and unchromicized membranes were clearly detected by splitting the mass of adherent omentum. The latter was adherent directly to the membrane, and more firmly still to the bowel at the periphery of the membrane. Under the membrane the denuded area was rough and scar-like, and there was no macroscopic evidence of regenerating peritoneum. Clearly, used in this manner, the membrane would not prevent adhesions.

Experiment No. III.—The abdomen of a dog was opened and two areas of the duodenum seven centimetres apart and each one and one-half by two centimetres in area were denuded of peritoneum, and the proximal one was covered with unchromicized Cargile membrane, while the distal one was left with its raw surface exposed. At the same operation an area two centimetres square on the anterior surface of the stomach was denuded of peritoneum and covered similarly with unchromicized membrane, but the latter was not anchored by suture. The abdominal wound was closed in the usual way. Nineteen days later the abdomen was reopened and firm adhesions were found at each site of denudation. Apparently they were as firm and as numerous where the Cargile membrane had been placed as where it had not been placed. A careful search revealed no Cargile membrane.

Experiment No. IV.—The abdomen of a dog was opened and four pieces of Cargile membrane were placed as follows: (*a*) A piece of unchromicized membrane was placed over a denuded surface one by two centimetres in size and anchored well towards the mesenteric attachment; (*b*) a piece of unchromicized membrane was placed over an undenuded surface and similarly anchored; (*c*) a piece of chromicized membrane was placed over a denuded surface of similar size and anchored, as above; and (*d*) a piece of chromicized membrane was placed over an undenuded surface and attached by sutures as in the foregoing. The number of sutures differed with each piece anchored, so that the several pieces could be recognized. Four days later the abdomen was again opened and thirty-five centimetres (fourteen inches) of the bowel, to which the four pieces of membrane had been attached, was resected and end-to-end anastomosis done. Adherent omentum completely covered and surrounded every piece of membrane. The adhesions were easily broken up, being so recent, but they were numerous. At the two places where the unchromicized membrane was placed, none of the Cargile membrane could be found macroscopically, though Dr. Ellis was able to find fragments microscopically. The chromicized membrane, however, was plainly visible where it had been placed. Neither had prevented adhesions, particularly at the periphery of the membrane. The resected portion of the intestine was submitted to Dr. Ellis for microscopic examination.

Experiment No. V.—A dog's abdomen was opened and an area one and one-half by four centimetres was denuded of peritoneum and covered with unchromicized membrane. It was anchored *in situ* as above explained. Ten centimetres distal to this, an area one and one-half by

two centimetres was similarly denuded, but left exposed without Cargile covering. The abdomen was closed and sixteen days later reopened. A mass of omentum covered the entire site of operation in each instance, and no membrane was found.

Experiment No. VI.—A dog's abdomen was opened and a surface one and one-half by three centimetres on the duodenum was denuded of peritoneum and covered with the unchromicized membrane, the edges being anchored as in previous instances. Ten centimetres distal to this a similar area was denuded and not covered with membrane. Eleven days later the abdomen was reopened and fairly firm adhesive omentum covered alike both areas. No membrane was found.

Experiment No. VII.—A dog's abdomen having been opened, an area one and one-half by two centimetres on the duodenum was denuded of peritoneum and covered with unchromicized Cargile membrane, the latter being anchored as above. Three days later the abdomen was reopened. A large omental graft had covered the entire site of operation. The membrane immediately covering the actual denudation had disappeared, but it persisted in the rest of its extent; that is, the centre of the sheet of membrane had been digested or dissolved by the raw surface. This showed that some element in the actual wound acted, probably in a digestive capacity, in dissolving the membrane in immediate contact. A portion of the intestine containing the field of operation was resected and submitted for microscopic examination.

Experiment No. VIII.—A dog's abdomen having been opened, a small area of duodenum was denuded of peritoneum, covered with unchromicized membrane which was anchored by sutures, and this in turn was covered by a piece of sterile rubber dam which extended well beyond the Cargile membrane; this, too, was in turn anchored by suture. Three days later the abdomen was reopened, and it was found that a mass of omentum and aplastic lymph completely covered the entire site of operation, including the rubber dam. I desired by this experiment to determine whether it was a phagedenic property of the omentum that destroyed the membrane, or was it granulation tissue, or was it peritoneal fluid? The mass was removed from the rubber dam; the latter was likewise carefully removed and no Cargile membrane was recognized macroscopically, though fragments were observed by Dr. Ellis microscopically.

Experiment No. IX.—This was a repetition of Experiment VIII, except that the abdomen was reopened on the sixth day instead of the third after operation. Practically, the same conditions were found, namely, the sheet of rubber dam, under which the Cargile membrane had been placed, was covered with an omental graft, and on examination the Cargile membrane had all disappeared to macroscopic view, though seen by Dr. Ellis microscopically.

Experiment No. X.—Experiments VIII and IX appeared to offer fair evidence that it was not the omentum *per se* that had destroyed the membrane, but it proved nothing as to the action of the peritoneal fluid. Accordingly, I placed a piece of unchromicized membrane, five centimetres square and made into a small roll, in a glass tube one centimetre in

diameter and seven and one-half centimetres long, and containing about a dozen small perforations; in another tube of about equal size was placed a similar piece of the chromicized variety. These tubes were closed sufficiently to prevent the escape of the membrane and placed loose in the peritoneal cavity of a dog. Fourteen days later the abdomen was reopened and both tubes were easily found. The tube containing the chromicized membrane was practically free, and when removed the membrane was quite softened, pale, and œdematous, but apparently little changed in other respects. It was delivered to Dr. Ellis for further examination. The tube which had contained the unchromicized membrane was wrapped about with omentum, but the membrane had entirely disappeared, leaving the tube empty. Clearly, the chromicized membrane was much the more resistant.

Experiment No. XI.—From the glass-tube experiments we had fair proof that the unchromicized membrane would soon disappear when placed in the abdominal cavity, without actual contact with the omentum. It appeared a natural deduction that the peritoneal fluid could itself be potent in dissolving the membrane. To exclude the phagocytic action of the leucocytes, at Professor Coplin's suggestion and under his direction, I placed a piece of unchromicized membrane three centimetres square in a celloidin capsule five centimetres long, containing salt solution. Pathologists state that this capsule will permit the osmosis of the body fluids, but leucocytes will not pass through its wall. The sealed capsule, with the contained membrane, was placed free in the abdominal cavity of a dog. On the seventh day the capsule was removed and opened. The membrane, aside from being œdematous and apparently thickened, was little changed macroscopically. There was little fluid left in the capsule. The membrane was submitted to Dr. Ellis.

Experiment No. XII.—The above experiment was repeated in every detail, except the celloidin capsule was not removed until the thirtieth day. It was easily found wrapped in a small mass of omentum. There was apparently no infection. Professor Coplin opened the capsule. It contained a milky, slightly blood-stained fluid, and the membrane, hardly recognizable as such, just at the point of disintegration. It had apparently almost dissolved. Professor Coplin examined some of the fresh fluid from the capsule under the microscope. The findings are detailed in the paper of Dr. Ellis.

Experiment No. XIII.—The left tendo-Achillis and the left posterior tibial nerve of a dog were exposed, and each was wrapped separately with four turns of unchromicized Cargile membrane. At the same operation the right tendo-Achillis and accompanying posterior tibial nerve were exposed and wrapped with three turns of chromicized Cargile membrane. The wounds were sutured. Fourteen days later the dog was killed and three centimetres of each tendon and its accompanying nerve were resected *en masse*. Examined macroscopically, the right nerve, around which the chromicized membrane had been placed, showed the membrane still in place; and while there was a mass of granulation tissue outside the membrane, the latter had plainly protected the nerves,

there being no macroscopic adhesions to the latter whatever, except at either end of the tube formed by the protecting Cargile membrane. The left nerve, about which the unchromicized membrane had been placed, showed no Cargile membrane macroscopically, though microscopic fragments were found by Dr. Ellis. And while adhesions to the nerve were distinctly fewer and less firm where it had been protected by the membrane than where it had not, yet fairly firm adhesions (for fourteen days) were present, and it was evident that the nerve had not been so well protected as where the chromicized membrane had been employed.

Experiment No. XIV.—Under ether the two tendons, as above mentioned, of a dog were exposed for a distance of five centimetres, and when each tendon was raised from its bed it was wrapped about by two turns of unchromicized membrane and the skin wound was closed. Twenty days later the dog was killed, and both tendons and the accompanying posterior tibial nerves were removed. Plainly, there were fairly firm adhesions to the tendon, more marked than at points not subjected to trauma. No membrane was found. The specimens were submitted to Dr. Ellis.

Experiment No. XV.—The right tendo-Achillis of a dog was exposed, lifted from its bed, and four turns of unchromicized Cargile membrane were passed around it, thus isolating it completely. The accompanying posterior tibial nerve was isolated, wrapped separately with two turns of membrane, and plaster dressing was applied to the dog's leg. It was hoped by immobilizing the parts that a better idea of the actual protection afforded by the membrane, if any, could be had. Inability to keep the wound aseptic necessitated the removal of the plaster dressing. Five days after operation the wound was reopened. A mass of granulation tissue surrounded the tendon and nerve, but not a vestige of Cargile membrane could be found. Plainly, it had afforded little or no protection. It could only be assumed that the granulation tissue would follow the usual course and result in scar tissue, thus causing adhesion, unless constant motion prevented.

Experiment No. XVI was a repetition of Experiment XV, except that, in addition to covering the nerve and tendon separately, a piece of Cargile membrane two and one-half by five centimetres in dimensions was made into a small roll wrapped about with fine silk thread by a number of turns and placed in the depth of the wound between the nerve and tendon. Nine days later the wound was reopened, and, while granulation and organizing tissue was plentiful, no Cargile membrane was found, not even the roll mentioned above, but the rolled-up silk ligature was easily found. Evidently the membrane had all been dissolved.

Experiment No. XVII.—The right tendo-Achillis and right posterior tibial nerve were exposed and wrapped separately with two turns of unchromicized Cargile membrane. The left side was treated in like manner, and the wound closed. On the fifty-fourth day after operation the dog was killed and each tendon and nerve was resected and examined.

With the exception of a very small amount of scar tissue about the tendons and nerves, they appeared normal. No Cargile membrane was seen. Specimens were submitted to Dr. Ellis.

EXPERIMENT No. XVIII was a futile attempt to determine whether or not Cargile membrane could be made to replace, with any degree of efficiency, the dura mater. The temporal muscles of a dog having been turned down from the side of the head, the skull was opened by trephining. It was intended to remove a portion of the dura and replace it with Cargile membrane. Hæmorrhage, however, was copious, and I contented myself with rolling up a piece of unchromicized Cargile membrane three by four centimetres in dimensions, making a roll the size of a probe. This was wrapped about with several turns of fine silk suture to retain the form, in the hope that I might identify it when again sought. It was simply placed under the flap of temporal muscles to determine the action of the body juices. The wound, however, suppurated and vitiated the experiment, and the membrane was not again seen.

EXPERIMENT No. XIX.—A dog's temporal muscles having been turned down, the skull was trephined, and by means of rongeur forceps an opening in the skull two by three centimetres in dimensions was made, a piece of dura one by two centimetres was turned back and resected. This was replaced by a piece of chromicized Cargile membrane, the edges being slipped well under the dura throughout the entire periphery. A suppurating wound vitiated the experiment; but the resistance of the membrane is shown from the fact that, when removed thirty days later, the membrane was still intact, though porous and brittle. It was submitted to Dr. Ellis.

Two other operations were performed to determine, if possible, the efficacy, if any, of Cargile membrane in the cranial cavity. My results, on the whole, were bad; infection, as a rule, vitiated the experiments, and only the four were tried. Judging from my work, however, I am inclined to believe from the frailty of the membrane and the difficulty of handling it, except in the dry state, that the unchromicized variety is without value in cerebral surgery. I am inclined to think better of the chromicized membrane for this purpose. It is much more easily handled in the presence of a moist surface, and is not absorbed for a much longer period.

This completed the series of experiments so far as they seemed of value for the purpose of record.

My estimate of the value of Cargile membrane in preventing adhesions in the situations under consideration is embodied in our joint conclusions at the end of the article.

I avail myself of this opportunity to express my gratitude to Professor Coplin for his interest in this research, and for invaluable laboratory materials placed at my disposal; to Professors Keen and Da Costa for valuable suggestions and material aid; and to senior students C. C. White, L. F. Milliken, and Richard F. Taylor for assistance in the operative work.

HISTOLOGIC STUDY BY DR. ELLIS.

My part in this investigation consisted in studying histologically a number of specimens obtained at operation or autopsy by Dr. Craig. The tissues were fixed in Heidenhain's or Bensley's fluid and finally embedded in paraffin. Sections were stained by hæmatoxylin with the addition of eosin or Van Gieson, Mallory's reticulum stain, polychrome methylene blue, and Weigert's stain for elastic tissue. Those stained by hæmatoxylin and Van Gieson were the most satisfactory for purposes of study. I am deeply indebted to Professor W. M. L. Coplin for advice and assistance during the progress of the work. The description can best be taken up seriatim as the specimens were obtained and according to the experiment numbers of Dr. Craig.

The first specimen studied was a piece of unused Cargile membrane, sections of which were mounted and stained to obtain a basis of comparison for that in the tissues. The infiltrated membrane is very brittle, and in many of the sections is broken into numerous fragments. This must be borne in mind in interpreting the later findings; breaking alone cannot be considered as evidence of actual destruction by the tissues. The membrane elects fibrous tissue stains and by them is colored deeply. The larger part appears homogeneous, but in many areas the membrane seems to be made up of several layers which are intimately fused. For this reason they are not clearly differentiated, but are indistinctly outlined by slight differences in stain reaction. These differences are not sufficiently definite to warrant the assumption that in the preparation of the material it is actually formed by assembling several layers. The membrane contains neither demonstrable cells nor cell nuclei.

Experiment II.—Intestine on which was placed Cargile membrane under four different conditions; specimen removed at end of fourteen days. A. Peritoneum denuded; chromicized Cargile. Over the operated area the peritoneum and longitudinal muscle are lacking. On the surface of the circular muscle and intimately connected with it is a layer of new fibrous tissue. At either margin of the denuded area, where the Cargile was folded upon itself, are from two to four layers of almost perfectly intact membrane. Between these layers, as well as separating them from the intestine, is new fibrous tissue. At both margins, beyond the Cargile, the omentum is firmly adherent. This new tissue also encloses the portions of the membrane still remaining. The whole area of adhesions thus appears to be surrounding and healing in the layers of membrane. Within the folds of the latter at one margin is a number of so-called foreign body giant cells, some of which are very large. The majority of these cells are in the new tissue at some distance from the membrane, but a certain number are directly upon it. Even where they are in contact with the Cargile, that material shows no evidence of degenerative action due to the cells, and phagocytic action by them is not demonstrable. Between the areas of adhesion at the margins of the denudation, Cargile is present only at some distance from the intestine, and there in the shape of short fragments that show some thinning. That it was broken by the knife in cutting may be inferred from the facts that the new fibrous tissue over the intestine beneath is firm and smooth, and that no adhesions of the omentum have formed. Sections lower in the block, from the undenuded margin of the described area, show practically the same condition at the borders where adhesions have formed. Between these borders the appearance is also much the same, except that a narrow zone of very loose fibrous tissue is on the surface of the peritoneum; this zone is continuous externally with a band of dense new fibrous tissue similar to that over the denuded area. At points quite broad bands of new tissue extend from the peritoneum across the comparatively clear zone to the superficial layer, and thereby anchor it firmly to the intestine; this attachment of the new tissue, however, is not so intimate as in the case of the exposed muscle in the denuded area. Sections stained by polychrome blue show the presence of a very few cocci arranged singly

and in pairs; morphologically they correspond to the ordinary pyogenic cocci.

B. Peritoneum denuded; unchromicized Cargile. The Cargile has essentially the same arrangement as in A. The folds at the margin of the denuded area are more fragmented, and the pieces show more disintegration than in the preceding instance. It is surrounded by the new tissue of omental adhesions. At one margin is the peritoneum and longitudinal muscle of a second coil of intestine that is firmly adherent at this point. Giant cells are not seen.

C. Peritoneum intact; chromicized Cargile. New fibrous tissue has formed on the surface of the peritoneum. The latter structure is dissociated, and through it the new tissue is extending into the outer muscle layer, where it substitutes certain of the fibres. As in the two preceding instances, there are dense omental adhesions beyond the margins of the membrane, and they extend inward and enclose the folds of that material. It is fragmented, conspicuously so between the adhesions where omentum is absent, but otherwise is fairly well preserved.

D. Peritoneum intact; unchromicized Cargile. This specimen is essentially the same as C, in which chromicized membrane was used. The membrane is slightly more frayed on the margins. Where the omental adhesions have formed and included the Cargile, the underlying peritoneum, as such, is no longer clearly demonstrable because of its disruption and intimate association with the new tissue.

Experiment IV.—Intestine on which was placed Cargile membrane under four different conditions; specimen removed at end of four days. A. Peritoneum intact; chromicized Cargile. On the surface of the peritoneum of half the circumference of the intestine is a layer of formative tissue covered by fibrin in which is entangled a great many red blood-cells. At some points are numerous polynuclear leucocytes. The peritoneum is infiltrated with leucocytes which also invade the longitudinal muscle. Slight suppuration has occurred on the surface of the exudate as shown by many irregular spaces in the fibrin net-work, some of which contain granular detritus and polynuclear leucocytes. External to the exudate and not intimately attached to it is the Cargile, which is present on the borders of the involved area only, the middle half having almost or entirely disappeared. The ap-

pearance of the specimen and comparison of it with similar tissues indicate that the Cargile over the central portion disappeared mechanically during preparation or cutting of the tissue. That part which is present is broken into long pieces, but otherwise is intact. The exudate beneath the membrane and that included in the free central area are identical in structure. There is no evidence of adhesions of any kind.

B. Peritoneum denuded; chromicized Cargile. The peritoneum and longitudinal muscle are lacking. Over the denuded area is a fibrinocellular exudate in which organization is beginning, fibroblastic tissue being present on the surface of the circular muscle, which is infiltrated with leucocytes. Over this exudate is Cargile, which is intact throughout. There is no exudate external to the membrane and no signs of adhesions. Sections from a second block of this specimen are from the undenuded margin of the described area. They differ but little from the denuded space. Organization of the exudate is slightly further advanced. The Cargile over the denuded and undenuded areas presents the same appearance. Sections stained for elastica show none in the newly formed tissue; that in the vessels of the intestine is unchanged.

C. Peritoneum intact; unchromicized Cargile. An exudate composed of fibrin and polynuclear leucocytes is on the surface of the peritoneum, which is also infiltrated with these cells. Organization is beginning in the deeper layers, where vascularized tissue has already formed. The Cargile membrane has entirely disappeared. No adhesions have formed. Giant cells are not present. Sections appropriately stained show the presence of a very few cocci differing in no way from the ordinary pyogenic types.

D. Peritoneum denuded; unchromicized Cargile. The peritoneum and longitudinal muscle are lacking. The circular muscle is infiltrated with leucocytes. On the surface is a thin layer of vascularized organizing exudate which is surmounted by numerous wavy fibrils of Cargile, appearing as if several sheets of the membrane had split a number of times and the layers had then broken into short fragments. Into the inner portion of this mass of membrane the formative tissue is extending. External to the membrane, for a part of its extent, are fibrin and polynuclear leu-

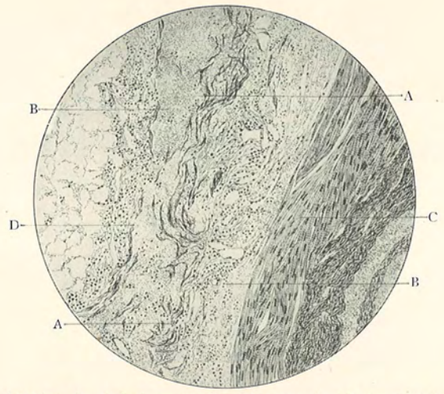

FIG. 1.—Intestine denuded of peritoneum and covered with non-chromicized Cargile membrane. Appearance at end of four days. (B. and L. ⅔ obj., 1 inch ocular.)
A A. Fibrillated and fragmented remains of the Cargile membrane.
B B. Organizing exudate on either side of the membrane. That on the left, especially in the upper part of the field, is still largely fibrinous.
C. Circular muscle of the intestine; at this point the longitudinal muscle was removed during denudation. To the right are the submucosa and basement membrane.
D. Disrupted serosa of the adherent omentum.

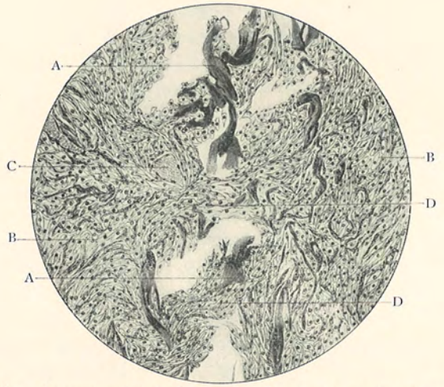

FIG. 2.—From the same section as Fig. 1. (B. and L., ⅙ obj., 1 inch ocular.)
A A. Fragments of the disintegrating Cargile membrane.
B B. Organizing tissue on either side of the membrane. That to the right is on the surface of the intestine; that to the left, on the surface of the adherent omentum.
C. Capillary blood-vessel in the new tissue.
D D. Two areas in which fibroblasts from either side have met through the fragmented membrane, thereby forming bands of adhesion.

cocytes. Covering the remainder of the Cargile and also surmounting the fibrinous exudate is a second layer of organizing tissue arising from the omentum, which here is closely adherent (Fig. 1). The serous covering of the omentum is disrupted, and the new tissue extends through it and for some distance into the underlying adiposa. At several points where formative tissue approaches the dissociated Cargile from both sides, the fibroblasts extend directly through the mass of fragments, forming continuous bands which at either end are vascular and becoming distinctly fibrous in character (Fig. 2). Sections from a second block of this specimen are from the undenuded margin. With the exception that the intestinal coats are intact, though infiltrated with the leucocytes, there is no essential difference from the denuded area. The adhesion of the omentum is the same as described when considering the preceding sections. In sections stained by polychrome blue, there are seen in the exudate moderate numbers of cocci arranged singly and in pairs.

EXPERIMENT VII.—Intestine of dog from which peritoneum was denuded and Cargile membrane applied; specimen removed at end of three days. Under the microscope, as macroscopically, no membrane is to be seen. The peritoneum is lacking over a considerable area, and, except at the extreme margins, the longitudinal muscle also has been removed. The central part of this denuded area is covered by a thick layer of exudate which is mainly fibrin, but also contains a few leucocytes, both mono- and polynuclear. This fibrinous exudate extends into the circular muscle, separating many of the superficial fibres. Beyond this, for more than half its breadth, the muscle is infiltrated with leucocytes, mainly polynuclears. Near the margin of the denuded area is a great deal of blood. The longitudinal muscle as it appears on the margin is densely infiltrated with leucocytes, and also contains numerous red blood-cells. Blood-vessels of the musculature are distended and contain an excess of leucocytes. The muscle fibres show varying degrees of atrophy. The fibrinous exudate extends for some distance over the peritoneum on either side of the denuded area, gradually thinning as the distance becomes greater. The sections are perfectly free from adhesions to omentum or other surrounding tissue.

EXPERIMENT VIII.—Intestine from which peritoneum was denuded and covered with Cargile membrane, which in turn was

covered by rubber dam; specimen removed at end of three days. Microscopic examination of the denuded area shows absence of the peritoneum and essentially all of the longitudinal muscle. On the surface of the circular muscle is a thick layer of exudate which is mainly red blood-cells, but also contains some fibrin and a few leucocytes. This extends into the muscle and separates many of the superficial fibres. The blood-vessels of the muscle are distended, and the inference is that from them hæmorrhage has occurred. Surmounting this mass of blood is a layer of Cargile membrane, which for a small part of its extent, at one end, is perfectly intact. Throughout the greater part of its length it has undergone more or less marked disintegrative changes. It is split into numerous thin layers or fibrils, and these are broken into pieces irregular in shape and of variable size, some being very small. The fragments are widely separated, occupying a space many times as broad as the normal Cargile. Between and surrounding these fragments is the exudate. External to the membrane is a layer of exudate nearly as thick as that between the membrane and the intestine, but differing greatly from it in constitution. The former is made up almost wholly of fibrin and polynuclear leucocytes, very few red blood-cells being present. Leucocytes are exceedingly numerous, and both they and the fibrin show some necrosis. At the point where the Cargile is intact, there is a very sharp differentiation between this external layer of fibrinocellular exudate and the blood beneath the membrane. Where the Cargile is disintegrating, the blood has passed through and permeated for some little distance the exudate externally; the polynuclear leucocytes of the latter have in turn penetrated the blood-clot, this admixture through the partially destroyed membrane being very conspicuous. Polynuclear leucocytes are at many points in direct contact with the fragments of Cargile, but there is no evidence of special disintegration at those places. Phagocytosis is not demonstrable.

Experiment IX.—Fold of chromicized Cargile membrane that was enclosed in a perforated glass tube and placed in peritoneal cavity; tube removed at end of two weeks. A small amount of reddish-colored material adhered to the end of the tube near the largest opening. Under the microscope this is shown to be made up of red blood-cells and leucocytes, the latter ten times

as numerous as the former and mainly polynuclear in type. Eosinophiles are not in greater proportion to other leucocytes than in normal blood. On section, the Cargile is found folded in many layers. The membrane is slightly thicker than normal, or when placed on tissue, and appears to be swollen, possibly by the imbibition of fluid. This appearance is further heightened by lessened density, as shown by the staining reaction and also by roughening or slight fraying of the surfaces. The membrane, however, is intact throughout. Between the layers are masses of partly disintegrated red blood-cells and numerous leucocytes, mainly polynuclear in type.

Experiment X.—Intestine denuded of peritoneum and covered by Cargile membrane, the latter being covered by rubber dam; specimen removed at end of six days. The peritoneum and longitudinal muscle are lacking. On the surface of the circular muscle is a thick layer of organizing exudate, the most advanced portions of which, bordering the muscle, are just assuming the characters of fibrous tissue; external to this is a well-marked zone of vascularized tissue, and on the surface a layer of fibrin and polynuclear leucocytes. The circular muscle also shows leucocytic invasion. In the fibrinous exudate at one point are a few fragments of Cargile membrane, the remainder having entirely disappeared.

Experiment XI.—Cargile membrane from a sealed celloidin capsule that was in the peritoneal cavity for seven days. The membrane is very much swollen, most of it being more than twice the normal thickness. The margins are decidedly frayed, presenting at some points a serrated appearance. Although the sections are very thick, the density is much lessened, many areas being semi-translucent; at points are small clear spaces or openings. Stains are taken with much less avidity than by the other specimens of the membrane studied. No cells are present. The appearance of this specimen is strongly indicative that the membrane is undergoing slow absorptive changes.

Experiment XII.—Cargile membrane and fluid from celloidin capsule that had been in peritoneal cavity thirty days. This specimen was first examined by Dr. Coplin, who kindly furnished the following description: "The capsule is surrounded by what appears to be fibro-fatty tissue, presumably a part of the omentum. Around the irregular and slightly rough end of the capsule, that

had been closed by ligature and sealing, the tissue attains a thickness of two to five millimetres. Towards the opposite or smooth end of the capsule the enveloping tissue hardly exceeds one millimetre, and at points is so thin that it is quite transparent. After incision of the soft tissue the capsule readily slipped out. Along one side it is dark in color, and in places is slightly wrinkled. It is evident there is fluid within, but it escapes at no point, even when gentle pressure is made upon the capsule. Upon opening the latter, the contained fluid is found to be of about the consistency of blood serum, slightly opalescent, possessing a faint pink tinge, decidedly cloudy, and containing scarcely perceptible irregular granules to which the cloudiness appears to be due. This fluid was examined in the fresh condition, also stained by Sudan III, methylene blue alone, and with eosin, and by Wright's stain. It is found to contain large quantities of granular material of a form usually characterized as cellular detritus. Some of the granules are grouped, and occasionally small, stringy granular bodies are observed. The granules vary in dimensions from one to four or five microns, and in some fields are collected into masses 100 or more microns in diameter. The larger number of granules are strongly acidophilic. With them are numerous spherical bodies possessing the general appearance of fat droplets and taking Sudan III strongly. Occasionally one sees what, by stretching the imagination, may be thought to resemble a shrunken cell of some kind; such bodies, however, are extremely rare. No structures resembling leucocytes or bodies corresponding to any histological structure can be identified. By proper staining methods, bacilli two microns in length and less than one micron in width are seen to be fairly abundant. These bodies could be recognized in unstained specimens, and were not motile. Cocci of ordinary dimensions, indistinguishable from usual pyogenic organisms of this group, are occasionally observed; they are not, however, in masses, nor are they abundant. The bacilli are far more numerous. The bacteria were not identified. The capsule also contains an extremely thin membrane-like structure, the dimensions of which are not determined." Later examination of this structure left little doubt that it was the much thinned Cargile membrane. It was left in salt solution for some hours; at the end of that time the salt solution was very turbid and the membrane had entirely disintegrated and disappeared. The value of this experiment, undertaken to determine the effect upon Cargile membrane of body fluids without the presence of cells, was vitiated by the occurrence of infection, and deductions therefore must be restricted.

The new tissue which had formed around the capsule is a band of varying breadth, the external portion of which is quite dense, newly formed fibrous tissue. Firmly adherent to three-fourths of the circumference is normal appearing adipose tissue. Towards the inner surface of the band, the fibrous tissue is less dense, and contains more cells. On this surface at points are leucocytes, both mono- and polynuclear in type. At other places, or along with the cells, is considerable fibrin. Both cells and fibrin show evidence of slight necrosis.

Experiment XIII.—Posterior tibial nerve which was isolated and wrapped with Cargile membrane; specimen removed at end of fourteen days. A. Nerve from left side, covered with four layers of unchromicized Cargile. Sections from one block of this specimen show between the nerve trunk and the fibrous tissue which half surrounds it the layers of the membrane. Of the four layers, the outer two, or those in contact with the tissues on either side, are intact, or nearly so. The two inner layers are not so well preserved. All four are separated some distance from each other in the wide space between the nerve and the enclosing tissue. The outer layers are partly enclosed by polyblasts or by recent fibrous tissue. This extends through the small breaks that are present in the membrane. Organizing tissue is also found between the layers of the membrane, but is not so prominent around the two inner as is that enclosing the two outer. No distinct adhesions are present in this section, the newly forming fibrous tissue on the two sides apparently being prevented by the membrane from uniting. A few giant cells are in the new tissue surrounding the nerve. One large one with six nuclei has in it a fragment of fibrous tissue that is roughened, and appears not unlike equal-sized pieces of Cargile membrane as it is found elsewhere. From the fact that these are typical "foreign body" giant cells developed only in the neighborhood of the membrane, it is reasonable to suppose the Cargile is the origin of the fragment in question. Whether or not this be an instance of phagocytic destruction and removal of the membrane, it is the only suggestion of such process found in the entire series of specimens. The membrane in those

areas where reparative processes are most active is splitting into fibrils, and between them polyblasts and spindle-shaped fibroblasts are insinuating their way (Fig. 3). In this manner the membrane appears to be disrupted and removed, or finally incorporated with the new tissue. Sections from another block of this specimen show the new fibrous tissue more prominently; at one point is a continuous band joining the two sides, though it extends in an irregular and zigzag manner among the fragments of Cargile. The appearance of the entire section is that uniform adhesions will finally result. A few giant cells are present, but they are not large, and are not in direct contact with the membrane.

B. Nerve from right side, covered with three layers of chromicized Cargile. Two layers of Cargile extend entirely around the nerve, except where broken in cutting or by destructive action of the tissues. Within these, directly upon the nerve, is a band of forming fibrous tissue, upon the surface of which is a fibrinous exudate containing many red blood-cells; this exudate is for the most part in contact with the Cargile. The areolar connective tissue, which was separated from the nerve when the Cargile was placed, is also covered by a layer of new tissue which is smooth and sharply limited as though repair was complete; it is nowhere penetrating or adherent to the membrane in the sections from A (Fig. 4). No giant cells are seen. Sections from another block of this specimen show new tissue advancing between the layers of Cargile, but no adhesions have formed.

EXPERIMENT XIV.—Tendo-Achillis and posterior tibial nerve. Two layers of Cargile around tendon, nerve not covered; specimen removed at end of twenty days. Cargile can be identified over approximately three-fourths of the circumference of the tendon. It is split into several thin layers and broken into short fragments. Throughout the entire extent, where visible, it is enclosed in a narrow space bounded by dense, newly formed fibrous tissue. For a part of the distance it is partially free in this space, which also contains red blood-cells. In such areas actual adhesions do not appear to have formed. At irregular intervals, however, fibrous bands unite the tissue on either side, and the Cargile is thus incorporated in a nearly healed wound; at many of these points the membrane has essentially lost its identity as a distinct structure. In several areas are numerous foreign body giant cells nested in small spaces, which they entirely fill or

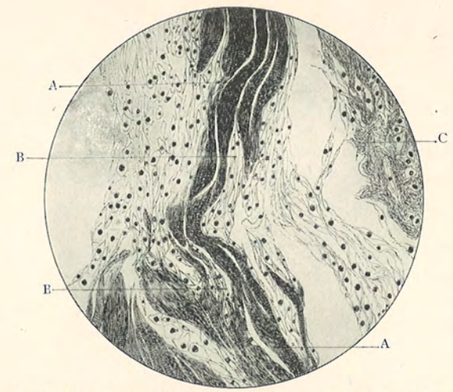

FIG. 3.—Layer of non-chromicized Cargile membrane surrounding posterior tibial nerve for fourteen days. (B. and L., $\frac{1}{12}$ homo. imm., 1 inch ocular.)
A A. Cargile membrane splitting into fibrils, but otherwise fairly well preserved.
B B. Spindle-shaped fibroblasts which are entering between the fibrils of the membrane. The appearance at and below the lower letter indicates that there is an intimate connection between the splitting of the Cargile and the intercalation of the formative cells.
C. New fibrous tissue internal to the membrane.

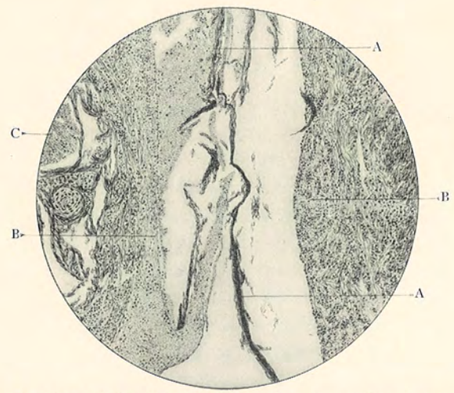

FIG. 4.—Three layers of chromicized Cargile membrane surrounding posterior tibial nerve for fourteen days. (B. and L., $\frac{2}{3}$ obj., 1 inch ocular.)
A A.—Cargile membrane. Two layers and a few isolated fragments of the third are still present. Varying degrees of fibrillation and fragmentation are shown.
B B. Newly formed or forming fibrous tissue bordering the space containing the Cargile. That on the right surmounts the connective tissue separated from the nerve when the membrane was placed; on the comparatively smooth border repair is sufficiently advanced probably to be beyond the adhesive stage. The new tissue on the left, surrounding the isolated nerve, is not so far advanced; on the surface and extending between the layers of the membrane is fibrinous exudate containing a few leucocytes.
C. Part of a nerve bundle immediately beneath the new tissue. Degenerative changes have rendered this portion of the nerve almost unrecognizable.

they are surrounded by loose areolar tissue. From these areas the Cargile has entirely disappeared. Phagocytosis by these cells is not demonstrable. In the fourth of the circumference where Cargile is entirely absent is a solid band of fibrous tissue, giving the impression that the membrane had not been present over this area.

EXPERIMENT XVII.—Tendo-Achillis and posterior tibial nerve. These were separated and each covered with Cargile membrane; specimen removed at the end of fifty-four days. In sections from this specimen can be found no evidence whatever of the membrane or the place formerly occupied by it. There appears to be but little excess of fibrous tissue over that which would normally be found in this location. At one point is a small circumscribed area made up almost entirely of giant cells surrounding fragments of a suture.

EXPERIMENT XIX.—Chromicized Cargile membrane from brain of dog; specimen removed at end of thirty days. This specimen is very brittle when mounted. Sections show that portions are of normal density, but slightly thinned. Still other parts are thickened, spongy in character, and stain less deeply than usual. The total bulk of the membrane appears to be slightly less than for normal membrane of the same extent; the loss, however, is not conspicuous.

The object of these histologic studies was to determine, if possible, the fate of Cargile membrane in the tissues, and also its effect upon those tissues it was intended to protect. The major portion of the findings has been embodied in our conclusions, but one point seems worthy of special emphasis. The irritative action of the membrane as a foreign body, especially in the peritoneal cavity, is so pronounced that it cannot be disregarded, and appears to be the principal factor militating against the otherwise beneficent possibilities of the material. In the case of raw surfaces it is difficult to estimate this action, but in every instance in which the membrane was placed over intact peritoneum, reactionary new tissue formed on the surface of the latter, which in many cases was disrupted and incorporated with the new formation. When the membrane is placed between two freshly incised surfaces, this

stimulus towards "healing in" of the foreign material is added to the reparative efforts common to all wounds, and their resultant action must be withstood if adhesions are prevented. It does not appear that Cargile membrane is able so to do.

Our joint conclusions are:

1. The most distant time at which we found unchromicized Cargile membrane existing intact, macroscopically, within the peritoneal cavity, was the fourteenth day; in most instances it had disappeared to macroscopic view much sooner. The earliest time at which we found the membrane had disappeared over the area of actual denudation was on the third day.

2. Unchromicized Cargile membrane when buried in living animal tissue, as when placed around tendons and nerves, or in muscle, is apparently absorbed sooner than when placed within the peritoneal cavity. In no instance was so much as a fragment of the membrane observed macroscopically so late as the fifth day, though in the fragmental state membrane was noted microscopically so late as the fourteenth day.

3. Chromicized Cargile membrane when placed within the peritoneal cavity or when buried in living animal tissue remains unabsorbed much longer than does the unchromicized variety. The two varieties doubtless bear relatively the same relation to each other, so far as absorbability is concerned, as do chromicized and unchromicized catgut.

4. While the unchromicized, and to a less extent the chromicized, variety will adhere fairly firmly to a surface denuded of peritoneum when such surface is relatively dry, yet neither can be depended upon to remain where placed, unless anchored by some method, in a situation which is subject to peristaltic activity.

5. A logical deduction from the results of the foregoing experiments seems to warrant the belief that neither variety of the membrane is of value in preventing adhesions within the peritoneal cavity. In every instance the membrane, until absorbed, appeared to act as a foreign body, and therefore as an irritant.

6. We believe from the results of our observations that

both varieties of the membrane are of value in preventing adhesions to wounded nerves and tendons when such structures lie in tissues which have been subjected to trauma, operative or otherwise. Our conviction is that for this purpose the chromicized is the more valuable.

7. We believe that several layers of either variety of the membrane when placed around tendons or nerves afford a safer and better protection than one layer.

8. We believe that, when used in the cranial cavity to replace destroyed or removed dura, the unchromicized variety would be exceedingly difficult to handle on account of its being unmanageable when moist; and we further believe, on account of the rapidity with which it dissolves, that it would be of no special value in this situation even though it could be used with ease. Owing to the facility with which the chromicized variety can be handled, its greater toughness and increased power to resist absorption, we believe that it would prove of greater value in replacing the dura.

9. Our studies indicate that the membrane is destroyed by a lytic substance, or substances, contained in the body fluid. The celloidin capsule experiments, even though bacteria were present in one, show that the membrane is softened, and at least partially absorbed by body fluids without the presence of cells. In the tissues it is split into fibrils, this change being accompanied or followed by the penetration of formative cells of the new tissue enclosing it. Fragmentation, disintegration, and absorption finally ensue. Phagocytosis may safely be excluded as a chief important contributing cause.

Dr. W. M. L. Coplin said the detailed experiments were to him interesting from two points of view: 1. From the purely scientific aspect of the question, and, 2, when viewed in the light of our knowledge regarding the healing in of foreign bodies. As a result of constant findings, the pathologist cannot regard a dead organized body as being other than an irritant when placed in the tissue. This is true even of isolated tissues in the body from which they are derived, detached periosteum or fragments of bone acting as irritants to the surrounding structures. Because

of this action, reintroduced tissue, in essentially every instance, is eventually absorbed and replaced by newly formed tissue. An interesting point is the method by which this absorption is accomplished. Following the studies of Metchnikoff and his school, there was a tendency to lay stress upon the action of phagocytes in the removal of the foreign body. The introduction of the celloidin capsule method of studying the effect upon bacteria of the body juices has furnished evidence, however, that lytic substances are present in the body fluids. This study of Cargile membrane appears to be the first investigation of the action of lytic substances upon foreign bodies in the tissues. Ziegler and his students have investigated the exudate cells found between embedded cover glasses, but in the experiments made by Drs. Craig and Ellis no cells could enter the capsules containing the membrane. Yet the membrane was destroyed or in process of solution, though no cellular bodies were in the fluid. In view of the question as to whether this process is a fatty degeneration, the contents of the capsules were very carefully examined for fat, but none was detected. The trend of opinion now is to look to the action of lytic substances in the destruction of irritating bodies, whether they are the cells of animals or actual foreign bodies that have been introduced. The absence of applied phagocytes in the present experiments is significant. Müller, in his studies of the absorption of teeth, and others have found the destroying cells applied to the tissue to be removed where they appear to secrete a material that destroys the tissue. Here the giant cells are not applied to the membrane; disintegration, however, is proceeding, an indication that lytic substances—possessing some of the attributes of familiar enzymes—are at work. Whether or not these substances come from the cells of the new tissue is a question at present under discussion; such origin is probable. The experiments make it clear that Cargile membrane acts as a foreign body, the chromicized and unchromicized varieties appearing to be equal in this respect. The practical application of the membrane, as to its harmful or beneficial effects upon the tissues, must of course be determined by the surgeon.

Dr. W. W. Keen said that, viewing the experiments from the practical side, the surgeon finds negative facts as important as positive results. The value of the paper lies in showing that the confidence of surgeons in Cargile membrane is largely misplaced, as it does not prevent adhesions. Dr. Keen would like to see the experiments continued and applied to several other materials. Silver and gold leaf both have been used in the cranial cavity, and found still present after long periods of time; can they be used elsewhere? The value of thin rubber dam and gutta-percha tissue should also be tested in this regard. Finally, the elastic rubber plaster employed by Brewer in his experiments to wrap arteries requiring repair of a solution of continuity should be tried to see if it would prevent adhesions. Good results were obtained by Brewer in the case of the arteries, though Dr. Keen is not sure that microscopic studies of the tissues were made. Continued studies will probably lead to the discovery of other substances that will be efficacious and more satisfactory in preventing adhesions.

Dr. John B. Deaver said he had used Cargile membrane quite extensively, in at least fifty or sixty abdominal sections, in covering denuded surfaces, stumps after hysterectomy, etc. His attention was first called to the material by the paper of Dr. Morris. All the patients upon whom Dr. Deaver used the membrane recovered, and, as reoperation was not necessary, the effects upon the tissues could only be surmised. The recovery of these patients was as uninterrupted as in case of those upon whom the membrane was not employed. Dr. Deaver never employs the membrane to cover raw surfaces if he can obtain a peritoneal or omental graft. From the manufacturer's stand-point, the membrane employed was in every instance aseptic.

Dr. Craig, in closing, said, in regard to the recovery of patients within whose abdominal cavity Cargile membrane was employed, that the material disappeared so rapidly it would probably not interfere with recovery. He has used the membrane in dispensary practice to cover open wounds, as ulcers, and in skin-grafting after the Reverdin method, and finds it is destroyed very rapidly over the raw surfaces.

RUPTURE OF THE TENDON OF THE BICEPS FLEXOR CUBITI.

A CASE OF RUPTURE OF THE LONG TENDON IN ITS CONTINUITY, AND ONE OF RUPTURE OF THE SAME TENDON AT THE GLENOID ATTACHMENT; OPERATION WITH SUCCESSFUL RESULT IN EACH CASE.

BY WILLIAM W. KEEN, M.D.,

OF PHILADELPHIA,

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CASE I.—Dr. John B., aged fifty-four years, who regularly practises athletic exercises, first consulted me, December 16, 1904. His father and mother suffered from rheumatism and neuralgia. He himself had had muscular pains from time to time, but never a distinct attack either of articular or muscular rheumatism. He has had several attacks of diarrhœa. Five years ago had a severe attack of pleuropneumonia. When twenty years old was only five feet tall and weighed ninety pounds; at twenty-four his height was five feet two inches and he weighed 106 pounds. After his attack of pneumonia he weighed but eighty-five pounds. At present his height is five feet six inches and his weight 125 pounds. When a young man, his health was so poor that he was advised to go to Colorado. His persistent athletic practices are readily explained as a means he has adopted, and very successfully, to obtain robust health. Even in the very cold weather of this winter, I found that he only wore an open meshed undershirt.

In June, 1902, a pupil by accident let an Indian club slip, striking Dr. B.'s right shoulder on the anterior surface while the muscles were tense. No ecchymosis followed, but for six months abduction of the elbow was impossible, not from pain, but from muscular inability to lift the elbow. Twice since then he missed catching a hand-ball and fell forward, striking on his right shoulder.

On December 8, 1904, in a violent muscular effort to catch a hand-ball, he suddenly felt a pain about the junction of the upper and middle thirds of the right arm, so severe that he stooped

and twisted his body to enable him to bear the pain. He noticed a lump on the arm, but paid little or no attention to it, as the pain quickly subsided. On December 13, he made a hand-spring, and again felt the pain at the same place.

On examination, December 16, I found that when he made forcible flexion of the forearm to a right angle and I resisted the flexion, the biceps' belly terminated at its upper portion suddenly, and I could not feel the tendon above that point. The upper end of the belly of the biceps also felt very flabby and soft, almost as if it were a hæmatoma, though not quite so soft.

My diagnosis was a rupture, more likely of the long head of the biceps. He had had but little pain, and his disability

FIG. 1.—The tortuousness of the tendon of the long head of the biceps.

FIG. 2.—Shows the fusiform swelling of the tendon below the bicipital groove and the mode of shortening the elongated tendon and suturing the two ends while held taut.

as a result of the accident both he and I estimated at about 25 per cent. The difference in outline of the two arms was more marked to the touch than to the eye, and hence I do not reproduce the photographs taken at the time.

In view of his athletic disposition, I advised and he accepted immediate operation.

Operation, December 18, 1904. I laid bare the biceps muscle and its upper tendons. The short head I found intact. The tendon of the long head lay tortuous like a snake (Fig. 1), extending from the body of the muscle upward. I had expected to find the tendon torn away from the belly of the muscle, but I found the two continuous. Traction on the tendon showed that

its attachment to the rim of the glenoid cavity was also firm. I dissected under the deltoid for a short distance upward till I reached the groove in the head of the humerus. About two centimetres below the groove began a fusiform swelling in the tendon extending downward about 1.5 centimetres (Fig. 2). This portion of the tendon was markedly discolored, almost black, evidently from blood effused within the sheath, but the sheath was intact. It was clear, therefore, that the tendon itself had been torn or ruptured within its sheath, and was much elongated, this partially destroying the function of the muscle. I severed the tendon just below the discolored portion, and, while each end was held taut overlapping the other about two centimetres, I sutured the two ends together with twenty-day chromicized catgut (Fig. 2). The arm was then placed on a rectangular splint so as to relax the biceps muscle. He went home, December 26, with the wound entirely healed.

January 26, 1905. He called to see me to-day. The splint was worn for two weeks after the operation, and the forearm was carried in a sling for two weeks more. At the end of that time he tells me he began doing athletic "stunts" with the arms, and has felt only the inconvenience which comes from weakness of the right biceps, due partially to non-use for a month. The muscular belly is quite flaccid as yet, and it is smaller than that on the right side by half a centimetre. The exercises he has taken have not been violent or prolonged, and presumably the biceps will improve very much in time.

[March 31. He is now practically as well as ever. The deformity of the biceps has almost disappeared.]

Case II.—Dr. J. Chalmers Da Costa has kindly given me the following notes of his case: "In May, 1904, a man, aged fifty-two years, while lifting a heavy bucket or pail, was suddenly seized with violent pain in the upper arm. He dropped the bucket, and for several days kept his arm bandaged and in a sling. I first saw him several days after the accident. Flexion of the forearm could be slowly executed, but was feeble, painful, and incomplete. On attempting flexion, the short head of the biceps contracted and the belly of the muscle became abnormally prominent, but the muscular 'bunch' thus produced was flabby and nearer the elbow-joint than normal. An incision disclosed the long head of the biceps curved like a snake. When pulled upon,

it came entirely out of the bicipital groove. A portion of the periosteum had been torn off with the tendon, evidently from the margin of the glenoid cavity. A portion of the upper end of the tendon was cut off and the tendon was attached to the short head by splitting the latter and suture. Primary union followed. At present, nine months after the accident, the arm and forearm are strong and active. He uses the arm for all purposes of hard work without pain. The biceps actively flexes the forearm; the short head is much enlarged."

Remarks.—Prior to the present cases there have been published only one case of operation for rupture of the belly of the biceps and one for rupture of the tendon.

Loos (*Beiträge zur klinischen Chirurgie*, 1900, Vol. xxix, p. 448) is in error when he states that Legueu operated. (See *Revue de Chirurgie*, 1895, Band xv, p. 897.) No operation was done by Legueu, and the cicatricial node in the tendon was not in the biceps, but the triceps tendon. The article of Loos just referred to and the earlier one by Maydl (*Deutsche Zeitschrift für Chirurgie*, 1882, Vol. xvii, pp. 306 and 513, and Vol. xviii, p. 35) covered most of the published cases up to 1900. These amounted to sixty-six in all.

I have not made further search of the literature than through my own card catalogue. This shows that there should be added to Loos's list the four cases reported by G. G. Davis (*Medical News*, 1895, Vol. lxvii, p. 121), Da Costa's, and my own cases herewith reported. These make a total of seventy-two cases. Loos states (p. 430, foot-note) that Petit has collected eighty-three cases of rupture, but that the paper had not been published in 1900, nor have I found it since.

It is a matter of surprise that a tendon should rupture in its continuity rather than that the muscular belly should yield or the tendon be torn loose from the muscular belly at the point of transition from the one to the other, or from the bony attachment of the tendon. There is, however, no doubt, as in my case, that this does occur.

I think Davis is, however, probably right when he says "the tensile strength of healthy tendon is so great that it is

my belief that true rupture is much rarer than is usually supposed, and that when a tendon does rupture, it is very likely to have been diseased." Yet, on the other hand, in a number of cases no prior disease was known. In the present case, in view of his prior history and later athletic life, there may or may not have been disease of the tendon.

Rupture of the biceps may take place at several points:

(1) In the belly of the muscle,

(*a*) Either that portion belonging to the long head;

(*b*) That belonging to the short head, or,

(*c*) The belly after union of these two portions.

(2) At the transition point between the muscular belly and one of the upper tendons.

(3) The transition point between the belly and the lower tendon.

(4) In the continuity of the tendon of the long head.

(5) At the point of insertion of this tendon to the rim of the glenoid cavity, or at least within the capsular ligament.

In some cases it is not easy to make an exact differentiation of the site of the rupture, hence all tables are to some extent unreliable. It is to be noted that *only in the operative cases has the exact* condition been verified by sight.

The combined cases of Loos, Davis, and this paper give for rupture of the muscle itself fifty cases as against twenty-two in the tendons, but of fifty-six cases in Loos's paper with more detailed histories to which Davis's four cases and these two are added, making sixty-two in all, there were forty-one of the muscle and twenty-one of the tendon. But from these twenty-one of rupture of the tendon six should be deducted as being at the point of junction of the tendon and the belly and the case of Legueu, which should not have been included. This leaves only fourteen cases of rupture of the tendon. The belly of the short head was only involved in two cases, and both of these were due to direct injury,—one in a threshing-machine, in which the tendon of the long head was also involved, and the other in an attempt at reducing a luxation of the shoulders.

In the larger series of Petit, the proportion is given as follows:

Rupture of the whole muscle, 21; of the long head, 9; at the transition point between belly and tendon, 7; of the lower tendon, 3; of the tendon of the long head, 43.

I think that there must have been some error in transcribing, for it would be extraordinary to have forty-three cases of rupture of the tendon of the long head and only nine of the muscular part of the long head. As stated, Petit's paper has not yet been published.

Besides the case here reported, there are only six cases of stretching or partial rupture of the long head similar to the present cases. Of all the cases reported by Loos, only four of rupture of the muscle and one of the tendon were caused, as in the present case, by muscular effort alone.

Of all the reported cases only two occurred in women.

The symptoms of rupture differ in rupture of the belly of the muscle and of the tendon. The muscular belly, either the whole of it, or (if the rupture involve, for instance, only the belly of the long head) a part or the whole muscle, becomes softened and loses its elasticity. Sometimes, in rupture of the belly into an upper and lower portion, there will be two tumors formed by the contraction of the two portions of the belly of the muscle, with a marked furrow between them from one to two fingerbreadths wide. At the bottom of this furrow, sometimes even the bone can be felt. If the rupture is at the junction of the tendon with the belly, this double tumor, of course, will not exist, but there will only be a tumor of the belly and none of the tendon. If the rupture be of the belly of the long head, the muscular belly of the biceps will be drawn towards the elbow. If the rupture be at the lower end of the belly of the muscle, the whole muscle will be drawn up nearer the shoulder.

In an excellent paper by White (*American Journal of the Medical Sciences*, January, 1884, p. 17), on dislocations of the long tendon of the biceps, the differential diagnosis between that lesion and rupture of the long head of the muscle is well

stated; and one other point of importance is mentioned, namely, that in rupture, the head of the humerus, not being held down by the long tendon, is approximated more closely to the acromion, and the shape of the shoulder correspondingly altered.

When the long tendon is ruptured completely or partially, the symptoms are less pronounced, partly because only a portion of the muscle is involved and partly because the sheath of the tendon to some extent replaces the tendon. Of course, there is much less ecchymosis and the discoloration is not pronounced. Only the portion of the muscle corresponding to the long head is flabby and has lost its tone, so that it feels like a cyst or a hæmatoma.

Unfortunately, in my case, I did not observe whether Hüter's symptom was present. He called attention to the fact that flexion of the forearm in supination when the biceps is relaxed is much less forcible than when the hand is in pronation, and the biceps is more tense and can contract to greater advantage.

Treatment.—The treatment in almost all cases has been either none at all, where patients have neglected to seek the surgeon till long after the accident, or by means of a bandage with or without a splint, massage, and electricity. I mention the latter only to condemn it save in the *later stages,* after the rupture is healed. Then it will do much good in restoring the functional activity of the muscle. Earlier than this it would but separate the two portions instead of approximating them.

In a few cases good functional results have been obtained, for it is possible sometimes, by manipulation and bandaging, to approximate the two parts of the muscle if the rupture be in the muscle, so that union will take place by fibrous tissue with but little loss of function. If the rupture be confined to one portion of the muscle, of course the chances of restoration of function are much better than when the whole of the muscle is involved. Yet, often in the cases of only partial rupture, loss of function is very marked. This is not only

due to the separation of the ends of the muscle or of the tendon and the lengthening of the muscle by the length of the scar tissue which fills the gap, but also from wasting of the muscle, from interference with its innervation.

It is strange that surgeons have so rarely operated. The cases in which operations have been done thus far are as follows:

1. Von Hochstetter (*Wien. med. Woch.,* 1890, p. 399). A very muscular man of forty-six years. Over two months after the injury, the upper end of the belly of the muscle and the tendon which had been torn loose from the belly were united with silk. After four months complete ability to work returned.

2. Bazy (*Bull. Soc. de Chirurgie,* 1895, p. 156). A man, aged forty years, in whom there was a complete rupture of the tendon of the long head within the joint or even detachment of the tendon from the glenoid cavity as a result of lifting a sack weighing eighty kilogrammes. The tendon was reflected upon itself so that the torn upper end was turned downward. Bazy resected the tendon and united the stump to the tendon of the short head and the coraco-brachial. The arm was placed in plaster at a right angle. After one month there was complete restoration of function.

3. In my own case, the patient at the end of a month resumed, to a moderate degree, his athletic occupation and is now quite himself again.

4. The case of Dr. J. Chalmers Da Costa. The lesion and the operation were identical with Bazy's case. The result was very satisfactory, entire use of the arm having been regained.

The most encouraging results from these four cases of operative interference and the poor result in many others not so treated, it seems to me, should lead to operative treatment of cases of rupture rather than to trust to the more or less uncertain results of the treatment by bandages and splints.

Dr. Gwilym G. Davis said that since reporting his series

of cases he had found one in a dissecting-room subject which supported the theory of the rupture of the tendon being due to disease of that structure. In the instance mentioned the tendon where it lay in the bony groove had almost entirely disappeared. Operation is indicated in cases of this injury in healthy individuals, provided they are seen early. Reasons why more cases of this injury are not operated upon are: 1. They are not seen early. 2. The disability often is comparatively slight, the other head of the muscle assuming the extra function. 3. The injury often occurs in people of rheumatic diathesis. It does not follow that severe trauma is necessary to cause rupture, as the tendon is often reduced to a mere thread. When such cases are operated upon, the tendon must be transplanted to the other head of the muscle.

Dr. Keen, in closing, said Dr. Davis's dissecting-room specimen was not subject to the criticism of specimens of supposed rupture of the muscle found in such bodies; the latter are more likely due to stretching, incident to moving the arms when rigor mortis is present, than to ante-mortem causes. In one case good results were obtained from operation three months after the injury, but if possible early operation is desirable. In cases not operated upon, the disability eventually is often quite marked. In the papers referred to are reported cases of laborers, porters, and soldiers who were rendered incompetent to perform their accustomed work. Only a few cases exhibit but little disability.

STATED MEETING, MARCH 6, 1905.

The President, Henry R. Wharton, M.D., in the Chair.

THE MATAS OPERATION FOR THE CURE OF ANEURISM.

Dr. John H. Gibbon presented a negro man, thirty-one years of age, whom he had subjected to the Matas operation for the cure of a popliteal aneurism. He stated that he believed this operation was as great an advance over the older ones as that of the Bassini operation for hernia is over its predecessors. The operation of Matas had been recently and completely described by the author in the Annals of Surgery for February, 1903. The possibility of performing this operation was suggested to Matas by the fact that the lining membrane of the aneurismal sac is the same as that of the vessel itself, and by the good results which have been obtained where arterorrhaphy has been practised.

In the case of sacciform aneurism where the sac is evacuated and the opening into the artery sutured without interference with the circulation, there can be no comparison between this operation and ligation. And even in fusiform aneurisms the advantages of this new method over the older one of ligation are paramount. Dr. Gibbon knew of no instance where the suggestion of Matas that it might be possible to reconstruct the artery by utilizing a portion of the sac in fusiform aneurisms had been done, but the method certainly seems worthy of trial. One of the greatest advantages in closing the arterial openings within the sac of an aneurism is the fact that the collateral circulation is not interfered with in the least possible way.

The Matas operation is applicable to all aneurisms in which there is a distinct sac, and in which the cardiac end of the main vessel can be thoroughly controlled.