INJURY AS A CAUSATIVE FACTOR IN THE DEVELOPMENT OF MALIGNANT TUMORS*

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One of the most difficult questions that confront the industrial commissions today is: What part, if any, does injury play in the development of malignant tumors? While numerous papers have been written on the subject and it has formed the chief topic of discussion at national and international congresses, no definite conclusions have been reached; at least, none that has been universally accepted. The judges and commissioners who have listened to the opinions of medical experts have found it exceedingly difficult to balance these more or less conflicting opinions. Since the adoption of the Workman's Compensation Act, not only in this country but in Europe, there has come up for adjudication a rapidly increasing number of cases in which a claim for compensation has been made on the ground that a local injury was the exciting cause of a subsequently developing malignant tumor.

The most difficult thing in discussing any medical question, especially a medico-legal question, is for the physician or surgeon to preserve a judicial attitude and to bear in mind that the attitude of an advocate has no place in a scientific discussion. While this is an ideal we have not yet attained, it is a goal toward which we should aim.

During the last twenty or more years a great change has taken place in the attitude of the medical profession toward the question of trauma and its relation to malignant tumors. Many who formerly refused to admit a causal relationship have since become convinced by the steadily increasing evidence, too conclusive to admit of question. Furthermore, it has been definitely accepted by the courts and compensation bureaus not only in the United States but in most other countries as well.

In France, the whole question took on importance from a medico-legal standpoint as early as 1897. Then the first law was passed. This outlined certain conditions the fulfillment of which meant the establishment of a causal relationship between an antecedent local trauma and a subsequently developing tumor. In 1907, at the French Congress of Surgeons, Segond read his classical paper on the subject, in which he presented six conditions; which conditions or rules have been accepted not only by the courts and compensation bureaus of Europe but of America as well; they have been accepted by Ewing in his book on "Neoplastic Diseases."

These conditions imply the following: (a) The authenticity of the trauma. (b) Sufficient importance or severity of the trauma. (c) Reasonable evidence of the integrity of the part prior to the injury. (d) Correspondence of the

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tumor to the site of the injury. (e) A date of appearance of the tumor not too remote from the time of the accident to be reasonably associated with it. (f) A diagnosis established by clinical and röntgenological evidence, supported when possible by microscopical examination.

The frequent association of trauma with malignant tumors impressed itself upon one of the writers (W. B. C.) as early as 1897,[1] when he presented a paper on the "Influence of Injury upon the Development of Sarcoma" before the New York Surgical Society. In this paper he analyzed 170 cases of sarcoma personally observed, forty-six of which gave a definite history of antecedent local injury. In 1910,[2] in a paper on "Injury as a Causative Factor in Cancer," he discussed the question more fully. At this time he reported 970 cases of sarcoma personally observed, in which there was a history of antecedent local trauma in 225, or 23 per cent.; and 250 cases of carcinoma, in which there was a history of injury in eighty-two cases, or 32.8 per cent. Of the latter group, 120 were breast carcinomas, of which fifty-two, or 42.33 per cent., gave a history of single antecedent trauma. A careful analysis of cases observed since that date shows about the same trauma-percentage: in a group of 360 cases of bone sarcoma personally observed from 1890 to 1926,[3] 181, or 50 per cent., gave a definite history of antecedent local injury. Since the publication of that paper we have observed 100 additional cases, making a total of 280 cases of sarcoma of the long bones associated with antecedent local trauma.

One of the reasons why the profession has been slow to accept the traumatic theory of tumors is because of the general skepticism on the part of the pathologists who, unable to find what they believe to be a clear or rational explanation of such causal relationship, have been inclined to attribute it to coincidence of a pre-existing tumor. We must bear in mind, however, that the pathologist does not come in direct contact with the patient, at least not in the early stages of tumor development. He has no first-hand information on which to base his opinion. On the other hand, the surgeon makes a physical examination. He learns on questioning the patient that the latter sustained an injury to a hitherto normal part, and that this exact part in the course of a few weeks or months has become the site of a malignant tumor. He cannot help but be impressed with the importance of the alleged injury and its possible relationship to the later-developing tumor.

In our opinion, the part that trauma plays in the etiology of malignant tumors is closely associated with the wider problem of the etiology of malignant tumors in general. We know that while a vast amount of study and research work has been done in an attempt to discover the cause of cancer, it still remains an unsolved problem. While the majority of pathologists at the present time undoubtedly believe cancer to be due to intrinsic causes (cellular theory), a considerable, and, we believe, increasing number, including surgeons who have had a large clinical experience with cancer in man, believe it is due to some extrinsic agent or microbic cause (parasitic theory).

In view of the increasing number of individuals who attribute their con-

dition, malignant tumor, to an antecedent local injury, it becomes more and more urgent for us to try to find out just what, if any, causal relationship does exist between the alleged trauma and the tumor. We cannot wait until the general problem of the etiology of cancer has been finally and convincingly settled.

Etiology of Malignant Tumors.—At present the profession at large, especially those engaged in cancer research, are divided into two main groups: *The first* and larger group maintains that malignant tumors are due primarily to some *intrinsic* cause, such as a congenital rest, or causes associated with the but little understood processes of cell development and cell restraint. Take, for example, a fracture. Here we find an immediate and very great out-pouring of new cells which form a callus or splint about the broken ends of the bone, and this callus quickly undergoes ossification with complete restoration of function. Why does this rapid multiplication of cells cease at the precise moment when no more are needed for the process of repair? We do not know, but we assume that there is some law called *growth-restraint*, which causes the process of proliferation to cease as soon as the damage has been repaired. Apparently Nature has some laws that govern the life and the death of cells. New cells are constantly being formed to take the place of old cells that have died or have been damaged by trauma, and when the damage has been repaired, the production of new cells ceases. In the case of a malignant tumor, however, the law of *growth-restraint* no longer functions. The multiplication of cells continues indefinitely, the new cells drawing their nutriment from the normal neighboring cells, thus weakening the individual until he finally dies of exhaustion or metastases.

In our opinion, there never has been any satisfactory explanation of the breaking down of the law of *growth-restraint*, nor of the difference in behavior of cells and tissues undergoing repair and those in the early stages of malignancy.

If we accept the theory of the intrinsic origin of cancer, the best explanation of the causal relationship of trauma is found in Ewing's book on "Neoplastic Diseases," third edition, p. 116. He states:

> "Important effects of trauma here are: (1) Solution of continuity, minute and gross; (2) separation of cell groups and tissue masses, as of skin, glands, bone; (3) necrosis of tissue; (4) confined hemorrhage requiring absorption or encapsulation; (5) accelerated regenerative processes with hyperemia, and new growth of specific cells, blood-vessels, and supporting tissue; (6) cicatrization.
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> "Some of these conditions are well-known elements entering into the causation of tumors, and the failure of attempts to produce tumors by experimental trauma in given cases does not reduce their importance when associated with other necessary predisposing factors."

The second and smaller group believes that all malignant tumors are of parasitic origin due to some unknown intracellular microörganism. If we accept the parasitic origin of cancer, the explanation of trauma as a causative factor is simple, rational and logical: the trauma furnishes a favorable soil for the growth of the organism. We have merely to assume that an extrinsic

microörganism or infectious virus has in some way, through the circulation, gained access to the cell where it acts as an irritant, causing rapid proliferation and multiplication of the cells. All the new cells contain a similar microörganism. This process continues indefinitely until a malignant tumor is formed. The latter increases in size and finally causes the death of the individual.

On this assumption we can explain the development of metastatic tumors in other parts of the body: the tumor progresses in size; new blood-vessels and blood spaces are formed into which the tumor-cells frequently gain access and are carried to distant parts of the body, thus forming the nucleus of a metastatic tumor. That this latter tumor has the same histological features as the primary tumor is explained on the ground that the organism is an intracellular organism, and both the cell and the organism are transported through the circulation, thus producing a new tumor of the same type of cell as the original.

Theory Held by Dr. William B. Coley.—This theory, already described in detail in a paper read before the American College of Surgeons, in 1924, is briefly as follows: That there exists an unknown microörganism or several strains of this microörganism which is widely distributed throughout the world so that practically everybody is exposed to it, and yet it requires a favorable soil for its development into a malignant tumor. I do not think the question of "favorable soil" has ever received due recognition in discussions on the etiology of cancer. In a paper ("Some Thoughts on Cancer Control," American Journal of Cancer, February, 1928), I gave a more detailed account of this theory and cited the evidence in favor of it.

I suggested in 1924 that a similar explanation might be applied to the causation and development of malignant tumors. This would explain why everybody does not contract the disease—only those whose local resistance has been broken down by one of many factors, *e.g.*, local trauma or chronic irritation or some change in the chemistry of the body fluids possibly due to changes in diet or water.

Another condition that furnishes a close analogy is osteomyelitis. About one-third of the cases of acute osteomyelitis give a history of antecedent local trauma. Furthermore, it has been possible to produce the same result experimentally: by injecting a rabbit with cultures of *staphylococcus aureus*, no harm results; and yet if following the injection the rabbit receives a sharp blow on the tibia or some other bone, osteomyelitis quickly develops.

We may assume that malignant tumors in man are due to a microörganism that is latent in the circulation and which gives rise to symptoms of malignancy only after the normal resistance of the cells is broken down, in some instances by local trauma. The microörganism thus finds a suitable soil in the damaged cell, forming a symbiosis with the cell and causing a proliferation and multiplication resulting in a malignant tumor.

One of the strongest arguments in favor of the parasitic theory is the inhibitive and even curative action of the streptococcus of erysipelas upon various types of malignant tumors. As early as 1893, one of the writers

(W. B. C.) stated he could find no rational explanation of this action except on the assumption that malignant tumors themselves are caused by some type of microörganism.

Recently Bouveret,[4] of Lyon, France, published an important monograph on the "Pathogenesis of Cancer," in which he strongly maintains that cancer is an infectious disease due to some form of microörganism, probably to some strain of streptococcus of erysipelas. He bases his argument chiefly upon the inhibitive and curative effect of erysipelas upon malignant tumors, and believes that this action can be explained in no other way.

Another strong advocate of the parasitic theory is Gregoraci, of Naples.[5] He believes that the body-cells and tissues of every individual have either an inherited or an acquired defense against bacterial infection. He states that while microörganisms may occasionally cause an acute infectious process accompanied by fébrile reaction, they more often in an ultramicroscopic state install themselves in the intimate texture of the tissues or cells and await a suitable soil for further development. Having found a permanent habitat, either isolated or in association with other organisms, they proceed to draw their nourishment from the body cells.

A critical study of the whole question of trauma and tumors has recently been made by Dr. Leila Charlton Knox,[6] of St. Luke's Hospital, New York. Knox's main argument against accepting a single local trauma as a causative agent in cancer is based upon the fact that in a large amount of experimental work by Lubarsch,[7] Ribbert[8] and others, it was found impossible to produce a cancer by any form of local trauma.

The large number of clinical observations covering a period of nearly one hundred years which, in our opinion, furnish convincing evidence of a causal relationship between injury and malignant tumors, Knox brushes aside as of little or no value. She gives the impression of being in accord with Askanazy,[9] who stated that the literature dealing with the subject was only a "collection of anecdotes." We doubt very much if the majority of students of this question will agree that the clinical observations made by the leading surgeons and pathologists of the world, beginning with Virchow in his classical book entitled *Die Krankhaften Geschwülste* (1863), and including a long line of distinguished pathologists and clinicians can be completely ignored or justly classed as "anecdotes."

According to Knox, Segond[10] discussed the statistical collections of case reports of tumors of alleged traumatic origin, and doubted that they have any value, quoting Auguste Comté to the effect that they represent only "empiricism under a mathematical disguise, for the most extensive statistics when they are derived from a variety of sources often have less value than fifteen minutes of good observation."

Quoting further from Knox: "Ribbert,[8] who thought that all the statistical collections were without value, stated that well-studied single cases of this type might be more convincing than any heretofore published statistics."

With this statement of Ribbert we are in complete accord. The present paper is not a statistical collection of case reports gleaned from many hospitals, each one with its own system of history taking, but is a critical study of a large group of cases personally observed.

As we have frequently pointed out, the question is one in which the pathologist is less able to give a careful, judicial opinion than is the clinical surgeon, for the reason that he is always dealing with second-hand or hear-say evidence which in the court of law is regarded as of little or no value. Whereas the surgeon who sees the condition in the early stages and obtains a

first-hand account of the injury, if he is a practitioner of large experience and has a knowledge of human nature, is able to judge the credibility of the patient and to weigh the importance of the evidence. Scientific medicine has not infrequently made grave mistakes in ignoring the oft-repeated stories and beliefs of laymen simply because no satisfactory scientific explanation could be found for them. No better example of this can be found than in the discovery of the origin of tuberculosis. For hundreds of years the laity held a firm belief that tuberculosis was a contagious or infectious disease, but this the leading medical authorities denied. They based their opinion on innumerable statistics, chief of which were those of the Bromptom Home for Tuberculous patients showing that in thirty-five years not a single nurse or doctor had contracted the disease. In the following year Koch discovered the tubercle bacillus.

War Injuries.—Many writers who refuse to accept a causal relationship between injury and tumors base their contention on the almost complete absence of malignant tumors following war injuries. Shortly after the World War, Dr. John B. Walker (a Colonel in the American Army) sent us notes on fifty-six cases of sarcoma that were associated with recent fractures or gunshot wounds. These were as follows:

39 cases of sarcoma of the femur and tibia treated by amputation; 23 dead.
5 cases of sarcoma of the humerus treated by amputation; 2 dead
2 cases of sarcoma of the radius and ulna treated by amputation; 1 dead.

In a study of material from the Sanitary Reports of the Prussian Army from 1899 to 1907, Löwenstein[11] found 241 cases of cancer; of these, thirty-nine, or 16.5 per cent., were post-traumatic. In view of the regular physical examinations made in these cases, exact data as to the time and locality of the injury were available.

Löwenstein, whose evidence Knox regards as more reliable than that of Löwenthal, in his monograph on "Accident and Cancer," reported 271 critically chosen cases, of which 121 proved to be sarcoma.

Another argument frequently advanced by opponents of the *traumatic theory* is, that the number of cases of local trauma occurring in the daily routine of life is very large, while the number of cases of malignant tumor associated with antecedent local trauma is very small. The statistics of accident wards of large hospitals showing thousands of injury cases with but few if any tumor cases, are cited.

This whole argument when properly analyzed loses most if not all of its force. To begin with, no one believes that trauma alone can produce a malignant tumor. Hence the large number of injury cases with but few malignant tumors. To produce a tumor, other factors are required, *e.g.*, a predisposition on the part of the individual, inherited or acquired, resulting in tissues or cells of too low-resisting power to withstand the invasion of the microbic cause of cancer. In some individuals this resisting power is so low that no external cause is required for the development of the cancer; in

others, the natural resistance must first be lowered by some external force, such as local trauma or chronic irritation, before the disease can gain a foothold. Hence we should expect malignant tumors to develop not after all injuries but only when there is a co-existence of all the factors mentioned, which would account for the very small number of cases associated with antecedent local trauma. In poliomyelitis we find a close analogy. Here there is undoubtedly a microbic agent or virus, widely distributed, to which a great many are exposed, and yet, even in an epidemic, a comparatively few contract the disease. The explanation is, that nearly all adults and the great majority of children have a high degree of resistance or immunity to the organism. This resistance is either inherited, or acquired by having had an attack of the disease so light that it was never recognized.

As a matter of fact, we believe that the actual number of cases of malignant tumors in which there was some form of antecedent local trauma is considerably greater than the apparent number based on a study of hospital histories.

Two years ago, one of the writers was called upon in a single month to testify as expert in two cases of sarcoma that had recently been under his care at the Memorial Hospital or the Hospital for the Ruptured and Crippled. In one case no mention was made of antecedent local trauma, and in the other the house surgeon had stated that there was no history of trauma. In the latter case, the man had been thrown off a high ice wagon, striking his pectoral region upon a cobblestone pavement; a few weeks later a rapidly growing sarcoma developed at the exact site of the injury. In the former case, the patient had slipped while carrying a ladder under his arm, forcing the ladder against the soft tissues of his axilla and causing a bruise; shortly afterwards, a highly malignant tumor developed, at the exact site of the injury.

Fortunately, the writer had a complete personal history in these cases, with accurate description of the nature of the injury and the dates. A claim was brought against the insurance companies in both cases and full compensation was allowed.

If the errors in these histories had not been discovered, some later investigator of the question of trauma and cancer would have recorded both as cases without antecedent injury. If such events occur in hospitals in which a special effort has long been made to obtain exact information as to presence or absence of trauma in every malignant tumor, it is easy to believe that an even larger percentage of errors occur in the larger general hospitals.

Again, many pathologists base their opposition to a causal relationship between antecedent local trauma and the development of malignant tumors on the ground that so-called scientific or laboratory evidence of the integrity of the part at the time of the injury is lacking. Strictly, this would call for excision of tissue at the site and time of the trauma, for microscopical examination, which is manifestly impossible. On the other hand, the rules or conditions laid down by Segond call for no such laboratory proof but are satisfied with clinical and, when possible, röntgenological proof.

To cite a personal observation: A man was struck a severe blow on the occipital region by a heavy wooden packing case, producing a typical hematoma two and one-half inches in diameter over the occiput. Under two weeks' local treatment this diminished to about one-half its original size; it then began to increase. An operation was performed three weeks after the injury for a supposed hematoma but instead there was found an osteogenic sarcoma which had completely destroyed both tables of the skull over an area two inches in diameter extending to the dura. The diagnosis was confirmed by Doctor Ewing. Under irradiation and Coley's toxins, the disease apparently disappeared. At the end of seven and one half years, however, the patient is living with severe pain from radium osteitis, but no evidence of recurrence.* In this case there can be no reasonable doubt that the trauma was a causative factor in the development of the sarcoma. To suppose a pre-existing tumor without any physical signs or symptoms in such a location calls for a stretching of credulity beyond the ordinary limits.

In another case, a woman, while walking along the street, was struck a severe blow on the breast by a batted ball, causing a distinct bruise, ecchymosis, and severe pain. No tumor or swelling had been noticed in this region prior to the injury, and none was noticed immediately thereafter. However, two months later she developed a hard, rapidly growing lump at the exact site of the injury. This was pronounced malignant. A radical amputation was performed but the patient died a few months later. In this case, to assume the presence of a pre-existing, unrecognized carcinoma at the exact site of the injury, in our opinion, again calls for an unreasonable amount of credulity.

If such cases of clear-cut history of antecedent local trauma were rare or isolated the assumption of a pre-existing tumor might be warranted; but when we find the number increasing in direct proportion to the care with which the clinical histories are taken then we must look for some more rational or more probable explanation.

Wainwright,[12] of Scranton, Pa., in his paper on "Single Trauma, Carcinoma and Workmen's Compensation," maintains that: "If we will admit that the relationship has been a true one, even in one case, we must consequently admit that it may likewise be a possibility in any other case in which this relationship comes up for serious consideration."

According to Samuel Johnson, "Experience becomes the great test of truth and is perpetually contradicting the theories of men."

While Knox is but little impressed by Löwenthal's [13] paper on "The Traumatic Origin of Tumors," the latter after nearly forty years still remains one of the most exhaustive clinical studies of the subject that has ever been made. It is based on a careful analysis of 800 collected cases reported since 1870, with references to 360 cases of malignant disease of undoubted traumatic origin reported prior to 1863 and cited in Virchow's "Pathologic Tumors." The latter, however, are not included in the statistical presentation of the 800 cases. It is interesting to note that there were 137 cases of traumatic carcinoma of the female breast. Of the 316 cases of sarcoma reported, 167 were sarcomas of bone.

The time that elapsed between the trauma and the development of the tumor is stated in 190 cases, as follows: one month or less, 135 cases; one month to one year, thirty-three cases; upwards of one year, twenty-two cases. The longest interim stated was forty-nine years. In a few cases from fifteen

* Shortly after this was written, evidence of a local recurrence appeared and developed rapidly causing death in September, 1933, eight years after the treatment was begun.

to thirty-four years elapsed before the tumor was noticed. Löwenthal gives a brief history of all these 800 cases.

Carcinoma.—While a causal relationship between a single trauma and sarcoma had been more or less generally accepted, the English courts up to 1912 declined to accept any such causal relationship in cases of carcinoma. The first report of a legally established case of traumatic carcinoma of the breast we owe to W. Sampson Handley,[14] Hunterian Professor of the Royal College of Surgeons, London, who has long been regarded as the leading authority on cancer of the breast in Great Britain.

According to Handley, this patient, a woman, was referred to him on March 26, 1912. She stated that on November 3, 1911, she had fallen over a beam, striking on the left elbow and the left breast. The arm had to be kept in a sling for three weeks. About January 1, 1912, she first noticed a discharge from the left nipple, and shortly afterwards a small lump was seen in the left breast, which proved to be a large, malignant, rapidly growing duct carcinoma.

The case was tried and "the jury found for the plaintiff and awarded 200 pounds damages."

Janet Lane-Claypon, one of the foremost English authorities on cancer of the breast, who was selected by the British Ministry of Health to help compile the "Public Health and Medical Subjects" in 1924 and 1926, took charge of the investigation of cancer of the breast. She analyzed the histories of 508 cases of cancer of the breast selected from the leading hospital in London. In this number she found a definite history of antecedent local injury in 136 cases, or 26.77 per cent.

She divides the entire series into two groups, *e.g.*, *Group A*, in which there was a definite history of trauma followed by bruising; and *Group B*, in which there was a definite history of trauma without bruising, at least no statement of evidence of bruising was made in the history.

Group A contains forty-one cases. These she compares with a group of controls or 1,526 non-cancerous breast cases which showed only thirteen cases in which there was a history of bruise with cancer, the difference being 52.3 to 5.9 per cent. In Lane-Claypon's opinion the results of this study would lead one to believe that there was a definite association between injury and the subsequent development of cancer of the breast.

Group B, containing ninety-five cases, was compared with 1,526 controls or non-cancerous breast cases in which only eighteen gave a history of previous injury. A comparison of the two groups shows 62.6 per cent. of the positive cancer cases with a history of injury and 3.57 per cent. of the controls.

In a study of one hundred consecutive cases of carcinoma of the breast observed at the Presbyterian Hospital, McWilliams[15] found a history of antecedent local trauma in 44 per cent.

Our own personal series of 205 cases of carcinoma of the breast shows seventy cases in which there was a definite history of local trauma or in which the conditions laid down by Segond were practically fulfilled, seventy-one cases in which it was definitely stated that there had been no antecedent injury, and sixty-four cases in which no notation was made as to the presence or absence of trauma. Considering only the seventy cases in which there was a definite history of trauma and assuming that the sixty-four cases in which no statement was made were not associated with injury, we have 34.1

per cent. of the entire series in which there was a history of antecedent local trauma.

The rôle played by trauma in the development of metastases in latent carcinoma has been discussed by Firket of the University of Liege, who reports an unusual case, one of the few on record, that illustrates this point. His patient, a woman aged forty-five years, had a carcinoma of the rectum for which he performed a radical Kraske operation in the spring of 1912. The patient made a complete recovery and remained in good health without any symptoms of disease in any other part of the body until May, 1916, when she let fall on her foot a heavy earthen bowl. While there was no open wound, a very definite, painful contusion developed almost immediately afterwards. The severe pain never subsided, and two months later, a definitely outlined, hard, non-fluctuating tumor could be made out. *Röntgen-ray diagnosis.*—Tubercular osteitis. The tumor increased in size rapidly and became ulcerated. Three months after the accident the foot had grown to an enormous size and was very painful. An amputation was performed, and on microscopical examination the tumor proved to be a cylindrical-cell carcinoma, the same type as the carcinoma of the rectum.

The history in this case is so precise that it would seem impossible to explain away the causative influence of the trauma on the supposition that there was a pre-existing tumor at the site of the injury. This adds one more to the rapidly increasing list of cases which, following the suggestion of the English surgeons, may be classed as *acute traumatic malignancy.*

The foregoing case closely resembles one reported by one of us (W.B.C.) in 1912, except for the important fact that in our case there was no long "period of latency" between the development of the primary tumor and the metastatic tumor; as a matter of fact, the latter was discovered before the primary tumor had been recognized by any one. The patient, a boy aged six years, was admitted to the Hospital for Ruptured and Crippled on February 20, 1910, as an ordinary case of left inguinal hernia. Operation disclosed an uncomplicated left inguinal hernia which was closed by the Bassini method. The wound healed by primary union and the patient was discharged at the end of three weeks. Seven weeks later he was readmitted with a large swelling in the inguinal region directly under the hernial incision, extending from the anterior superior spine to the upper scrotum, not involving the testicle. The swelling was entirely painless. It was first noticed the week previously by the family physician who had been called in for what was supposed to be an ulcerated tooth, and who, on learning that the patient had been operated upon for a hernia, of his own accord examined the scar and found the swelling described.

On readmission examination showed a fusiform, sausage-shaped swelling, beneath the skin, extending the entire length of the hernial incision. The first impression was that we were dealing with some inflammatory exudate, but there was no fluctuation nor tenderness on pressure, no pain, and no temperature. The skin was normal in appearance. In consistence the swelling was firm but not hard, and from the clinical features, particularly from the "feel" of it, a diagnosis of sarcoma was made by one of us (W.B.C.).

On further questioning it was learned that the patient had had two teeth extracted the week previously because of ulceration. No one had suggested that the condition of the mouth might be due to a neoplasm and not inflammation. On carefully examining the jaw it seemed to me (W.B.C.) quite evident that we were dealing with a malignant, not an inflammatory, condition, and that in all probability this malignant tumor of the jaw antedated the tumor of the groin and had probably been present at the time of the operation although not sufficiently advanced to give rise to any symptoms. Sections from the tumor of the jaw and from the groin were examined by Doctor Ewing, who pronounced both to be round-cell sarcoma. The tumor proved to be a highly malignant

one. After a very brief course of toxin treatment, or two weeks after his entry, the patient was removed from the hospital because of family troubles. Even in this short time the disease had advanced with great rapidity, especially the tumor of the jaw, which had extended up in the orbit almost completely closing the eye. At the same time the glands of the groin and iliac fossa had become involved. The patient died three months from the time the jaw tumor was discovered.

While this is apparently an unique case little if any reference to it has been made in any of the literature on the subject. The most rational explanation of this case is that some of the cells of the unrecognized tumor of the jaw, carrying with them in their nuclei the unknown microbic agent, entered the circulation, but caused no metastases until the local resisting power of the normal body cells was lowered by the trauma of the hernia operation a few weeks before. As a result of this trauma, the exudate and the slight hæmorrhage associated with the operation, furnished just the soil suitable for the development of the organism, hence the rapid development of the metastatic tumors.

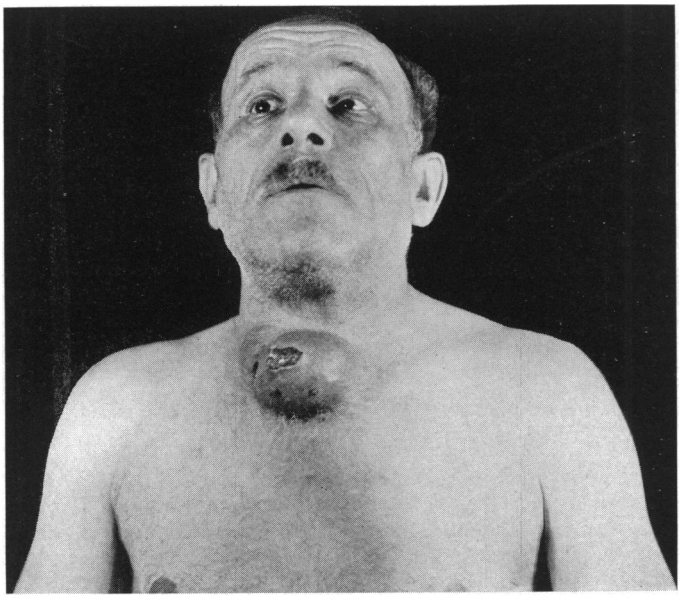

FIG. 1.—Carcinoma of tissues over sternum developing two weeks after severe blow. (See Case I.)

The following case we believe represents the most convincing example of *acute traumatic malignancy* in carcinoma that has ever been reported:

CASE I.—A. K., male, aged fifty-nine years, who, while performing his duties as a watchman on November 6, 1931, fell downstairs, receiving a severe blow over the upper part of his sternum from a metal clock that he was carrying. About two weeks later (Fig. 1) a small purplish area appeared in the upper portion of the sternum at the exact site of the injury. This soon began to increase in size and became protuberant. It grew very rapidly, and in the latter part of December, 1931, the patient was admitted to Fordham Hospital. An aspiration needle was introduced into the tumor several times in the belief that it might be an abscess. On January 13, 1932, the patient was referred to Dr. William B. Coley.

Physical examination at this time showed a mass the size of half an orange situated over the upper portion of the sternum, extending above the sternum, and infringing on

the neck over the thyroid gland. It was about three and one-half inches in diameter, and elevated two inches above the normal surface of the sternum. It was purplish-red in color. There were several areas slightly ulcerated and discharging at the site of the previous aspirations. The tumor was firm in consistence over the larger portion—in fact, it was markedly indurated and characteristic of a carcinoma rather than a sarcoma. It was ulcerated over the most protuberant portion, and softer, almost semi-fluctuating over some areas. There were a number of outlying glands along the cervical region, and marked enlargement of the glands in the left axilla. Some of the latter had reached the size of an English walnut, were hard, and typically carcinomatous in character.

The patient was admitted to the Memorial Hospital January 15, 1932, where an aspiration biopsy was performed, and the clinical diagnosis of carcinoma was confirmed microscopically by Doctor Stewart. The condition was so far advanced that it was regarded as hopeless by all who saw the patient. Röntgen therapy had no effect in checking the progress of the disease. Pulmonary metastasis developed in a few weeks and the patient died on February 18, 1932. The entire duration of the disease from the time of the injury until death was only a little over three months.

In this case it was difficult to reach any other conclusion than that the single local trauma was the exciting cause of the disease.*

In another case, a man while working in a machine shop was struck over the malar bone by a piece of metal. A swelling appeared almost immediately; this never subsided but increased rapidly in size. At the time of the patient's admission to the Memorial Hospital, it had reached the size of a goose egg. While it appeared more like an inflammatory condition, operation by one of us (W.B.C.) revealed a malignant tumor. This diagnosis was confirmed by Doctor Ewing. The tumor, which had been removed as completely as possible, recurred promptly, and the patient died within three months.

These two cases, in our opinion, furnish convincing evidence of the occurrence of *acute traumatic malignancy* in carcinoma as well as in sarcoma.

The following case is another interesting and convincing example of *acute traumatic malignancy*. I am indebted to Dr. William L. Watson for the history.

CASE II.—D. B., female, aged twenty-one months, on February 21, 1933, while playing on the floor, crawled under the gas range. She had difficulty in getting out, and becoming frightened, struck the top of her head against the range. The mother noticed a small abrasion on the scalp, but no bleeding. On the following day while bathing the child she found a small lump at the side of the injury. Five days later, no improvement being noticeable, she took the child to Dr. J. Edgar, of Jersey City. He regarded the lesion as a hematoma and prescribed local applications and gentle massage. He examined the patient again one week later, when the hematoma showed some evidence of softening, but did not advise any treatment. April 6, or forty-three days after the injury, the mother again consulted the doctor, calling his attention to the change in color of the swelling (it had become dark purplish) and to apparent increase in size. He, in consultation with another physician, then made a diagnosis of sarcoma, and referred the patient to the Memorial Hospital April 11, 1933, where she was placed on the service of Doctor Watson.

Examination on admission showed a firm, pale, purplish tumor mass measuring 6 by 5½ by 2½ centimeters, situated in the vortex of the scalp, and involving the skin. Numerous firm, hard subcutaneous nodules ranging in size from 2½ to 3 centimeters were scattered throughout the occipital scalp and neck.

Provisional diagnosis. (Dr. F. Stewart.) Endothelioma of scalp with metastases to both sides of the neck.

Treatment. Low-voltage X-rays.

* At the trial the Insurance Company made no attempt to deny a causal relationship, and the referee awarded full compensation.

By April 26 the primary tumor had apparently disappeared and the metastatic masses had practically vanished. A röentgenogram taken at this time showed no definite evidence of bone involvement. An aspiration biopsy was performed, and the following microscopical diagnosis made: unclassified round-cell malignant tumor, possibly endothelial myeloma.

In the foregoing case we believe it would be difficult if not impossible to apply Knox's method of reasoning, *i.e.*, that there must have been a pre-existing tumor at the site of the trauma. Here we have a young child with very little hair on her head, who was bathed daily by her mother. The latter is positive that there was no lump or swelling of any kind prior to the injury. The small lump or hematoma did not develop until the day after the injury and then, instead of subsiding as an ordinary hematoma would be expected to do, it slowly increased in size. Forty-three days later it had reached the size shown in the accompanying illustration (Fig. 2) and had metastasized.

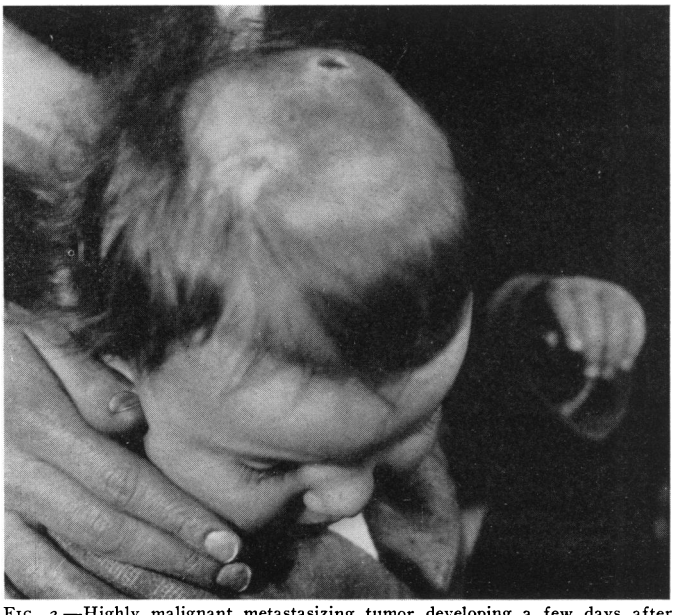

FIG. 2.—Highly malignant metastasizing tumor developing a few days after local trauma. Patient now has general metastases. (See Case II.)

Neither do we believe that Knox's method of reasoning could be applied in our Case I, A. K., which in many ways is similar to the preceding case. Here there is every reason to believe that the tissues over the upper sternum were normal until the time of the injury; there was no evidence whatever of a pre-existing tumor. The swelling did not develop until nearly two weeks after the injury, and was then regarded as either an abscess or a hematoma. In this case, as in the preceding, extensive metastases to the glands of the neck developed but in an even shorter period, *i.e.*, two weeks after the beginning of the tumor and four weeks after the injury.

The question, why a single trauma is capable of changing a pre-existing benign tumor of long standing into a malignant tumor, is one that has been

occasionally referred to in monographs and text-books, but we believe the following case is the only one which has come before the courts for adjudication. According to Ewing, a "pre-cancerous condition may be precipitated into a malignant process by injury. Examples are wounds of a psoriatic tongue by the teeth, injuries of the breast altered by chronic mastitis, and incomplete surgical removal of indolent ulcers, mucous polyps, fistulous tracts, and benign tumors."

In the following case one of the writers (W. B. C.) testified as a medical expert in July, 1932:

CASE III.—Multiple malignant tumor apparently caused by single local trauma.

W. J. N., male, aged sixty-two years, August 29, 1931, was injured in an automobile accident. The sedan in which he was riding was crashed into by a bus, the impact being of such force as to push the sedan forward, up a small embankment, and over on its side. The plaintiff, who was sitting beside the driver, was thrown to the left, striking his leg against the gear shift and emergency brake. He suffered a dislocation of the left shoulder, and felt sore and bruised all over, especially over a small tumor, about the size of a hazelnut, situated in the middle of the right leg, which had existed without any appreciable increase in size for fifteen or twenty years. The family physician, Doctor Bloom, who was called in the same evening, examined the shoulder only, no other part of the body. It was not until five or six weeks later that the plaintiff showed his leg to the doctor. He stated that about three or four weeks after the accident he noticed an area of inflammation on the right leg about a quarter or three-eighths of an inch away from the lump. Six or possibly eight weeks after the injury he began to feel intense pain in the lump on his leg. Three months after the accident the lump had grown to the size of a very large hen's egg. This same lump had been noticed by Doctor Bloom three or four years prior to the accident, and in the belief that it was a sebaceous cyst he considered the possibility of a surgical removal. It was normal in color, of fair consistence, and freely movable under the skin. It had remained practically stationary in size during the period of his observation, but examination five or six weeks after the accident showed it to have markedly increased in size. On his advice, it was removed on December 15, 1931.

Microscopical Diagnosis.—Mixed spindle- and giant-cell sarcoma, malignant.

After three or four weeks' X-ray treatment, a second operation was performed in January, 1932, and in April, 1932, the leg was amputated about six inches above the knee.

The controversial question in this case was, whether or not the injury sustained by the plaintiff in the accident was the cause of the sarcoma which developed on his leg and required its amputation. The plaintiff maintained that the growth on his leg had been there for fifteen years, a benign, quiescent nodule, of firm consistence, movable under the skin, and that in all probability it would have remained as such throughout his lifetime but for the intervention of the accident. On the other hand, the defendant claimed that the growth was at the time of the accident and always had been a neurogenic sarcoma, such as it was found to be when the first operation was performed, and that it was not caused by the injury received in the accident.

An eminent pathologist who testified as an expert in behalf of the plaintiff expressed the opinion that the injury or blow received on August 29, 1931, was competent to stir up and make malignant the quiescent nodule on the man's shin. He stated that he had seen two cases of neurogenic sarcoma in which the growth had followed immediately after an injury.

One of the present writers (Dr. William B. Coley) also testified as an expert in

behalf of the plaintiff. In his opinion the blow on the leg on August 29, 1931, was a competent producing cause of the sarcoma or malignant condition which was found some three or four months later. He cited cases of neurogenic sarcoma coming under his own observation, in which a malignant tumor had developed shortly after an injury and at the exact site of the injury, the diagnosis being confirmed by microscopical examination and the fatal termination of the disease. He also cited two cases of quiescent pigmented moles which shortly after a local trauma became rapidly growing malignant melanomas.

Another eminent pathologist who testified as an expert in behalf of the defendant expressed the opinion that the plaintiff's condition was the natural history of a neurogenic sarcoma. The latter, he stated, has its own mode of growth and behaves as it does for causes that are inherent in the original tumor. He admitted the possibility of an adequate trauma causing a quiescent tumor to growth more rapidly.

Excerpts from Ewing's book on "Neoplastic Diseases" were read, as follows: "Mechanical trauma is an important factor in the causation of tumors. . . . The predisposing factors take many forms; there may be a benign or a minute malignant tumor in the tissue before the injury.

"Second. The precancerous condition may be precipitated into a malignant process by injury. Examples are wounds of a psoriatic tongue by the teeth, injuries of the breast altered by chronic mastitis, and incomplete surgical removal of indolent ulcers, mucous polyps, fistulous tracts and benign tumors."

The foregoing is sufficient to give the facts of the case and to show the conflicting opinions expressed by the experts. After nearly a week of argument the case was submitted to a jury who rendered a verdict of forty thousand dollars in favor of the plaintiff. This amount was reduced to twenty-five thousand dollars by the court. An appeal from this decision was made and carried before the Appellate Division of the Supreme Court on April 6, 1933. The decision was rendered July 14, 1933, affirming the first decision.

Intrathoracic or Intra-abdominal Tumors.—While it is now very generally admitted that a single local trauma may be an exciting factor in the development of a malignant tumor at or near the external surface of the body, very few are willing to admit such a causal relationship in cases of intrathoracic or intra-abdominal tumor. Knox,[6] in her review on trauma and tumors, stated "that serious injuries to the chest are so frequent and pulmonary tumors so rare that, statistically, a causal relationship is not even suggested." On the other hand, Aufrecht[16] regarded severe trauma which "does not produce laceration of the pulmonary tissue, but only molecular disturbances of an unknown character," as an important immediate cause of carcinoma of the lungs. He cited four cases personally observed in which the pulmonary carcinoma was preceded by severe trauma. These cases were regarded as of sufficient importance for Ewing to refer to them in his book on Neoplastic Diseases (*loc. cit.*).

In a recently reported case of primary carcinoma of the lung, Wells and Cannon[17] offer what we believe to be most convincing proof of a causal relationship between the carcinoma and the trauma which preceded it. This case is briefly as follows:

Male, aged fifty years, had always been in good health until September 1, 1926, when he was knocked down by an automobile. Severe pain in the chest followed. A röntgenogram taken on the next day showed a fracture of the left third, fourth and fifth

ribs in the mid-axillary line. There was also distinct evidence of traumatic injury to the lung, namely, hemoptysis and a subcutaneous emphysema extending over the entire body. No evidence of any neoplasm in the lung was revealed by the röntgenogram. The patient made an uneventful recovery and seemed to be in good health until the following August, when he complained of pain in the left side of the chest. A cough developed, and while symptoms suggestive of pulmonary tuberculosis appeared, no tubercle bacilli could be found in the sputum. Röntgenograms taken at this time revealed evidence of cancer in the left upper lobe of the lung. The clinical course was steadily downward ending in death on August 17, 1928, or one year after the development of symptoms and barely two years after the injury to the left lung.

A *post-mortem examination* made by Doctor Paul R. Cannon revealed the presence of a primary carcinoma of the upper lobe of the left lung, with metastases to the mediastinal and left supraclavicular lymph-nodes, in the retroperitoneal peri-aortic lymph-nodes as far down as the bifurcation in the right suprarenal gland and both kidneys. There was a thickening and an irregularity in the third, fourth and fifth left ribs in their middle thirds from the healed fractures There were no tumor nodules in the right lung.

Histological Examination showed the tumor to be composed of cells which generally appeared elongated, consisting chiefly of nucleus with little cytoplasm, thus much resembling sarcoma cells, but they tended to form alveoli, did not secrete collagen, and often exhibited a palisade arrangement. In no place did the cells exhibit a characteristic epithelial structure, nor did they form tubular structures, secrete mucin, or undergo keratinization. In other words, the structure was that of the type of lung tumors that has often been described in the earlier literature as sarcoma and later as mesothelioma, and which has been interpreted by some as a tumor arising from the flat epithelium of the alveoli.

According to Wells and Cannon, this case "seems to present as nearly completely satisfactory evidence as one can hope to secure of the development of a primary carcinoma of the lung as a direct result of a single traumatism to the lung tissue. Röntgen plates of the chest made immediately after the injury show that at this time there was no evidence of a carcinoma of the lungs demonstrable by this means. There is conclusive evidence of traumatism to the lung (hemoptysis and severe subcutaneous emphysema). The interval between the time at which the traumatism was received and the appearance of symptoms of the cancer of the lung (eleven months) is entirely in harmony with the assumption that the neoplastic growth was caused by the traumatism of the lung, and the duration of life after this time (twelve months) is in keeping with the rate of growth to be expected from a tumor reaching the observed state in the first eleven months after the traumatism. . .

"Of course, it is not possible to say that there was not already a carcinoma, too small to be detected in the Röntgen film, growing in the part of the lung that was traumatized at the time of the injury. But in view of the extreme infrequency of primary carcinoma of the lung arising in the periphery of the upper lobe, to support such an explanation of this particular case requires a stretching of 'the long arm of coincidence' to the vanishing point."

Personally, one of the writers has observed only one case of intrathoracic tumor in which he was fully convinced that the single trauma experienced was the exciting causative factor of the development of the tumor. This case later became one of the most important medico-legal cases that has ever come before compensation boards in this country. It was reported by Doctor Coley at a meeting of the New York and New England Association of Railway surgeons. In certain respects it closely resembles the case reported by Wells and Cannon.

CASE IV.—L. D., aged thirty-six, weight 200 pounds, had always been well until July 30, 1921, when while working, he was caught between scaffold and stone coping of roof, receiving a severe bruise over the ninth, tenth, and eleventh ribs on left side. Felt very sharp pain and great difficulty in breathing, which continued so that he found it impossible to sleep while lying down. Three days after injury, physician was called who found swelling, ecchymosis and tenderness at site of injury. He tried to do light work for two or three weeks, but gradually became worse and coughed up blood, so gave up working. No X-ray taken at time of accident, but six weeks after injury, X-rays showed what was taken to be exudate in pleural cavity at site of injury, and diagnosis of traumatic pleurisy was made. Patient grew rapidly worse and died, January, 1922. Full course of disease less than five months. Autopsy showed malignant tumor involving ninth, tenth, and eleventh ribs at exact site of injury, also tumor of left lung, tumor of right lung and liver. Microscopical examination by Doctor Ewing: epidermoid carcinoma.

During period of five years case came before four referees. Attorney for plaintiff (widow), claimed injury was competent producing cause of death. Attorney for defendant (Insurance Company, carrier), claimed cancer was primary in lung for considerable period before injury, and that injury had no causal relationship with tumor, nor did it in any way accelerate condition.

First trial: Verdict in favor of defendant.

Second trial: Lasted a year, due to various postponements; referee went out of office.

Third trial: Case reheard from beginning. Expert for defendant, pathologist of great experience, testified that histological type of tumor, epidermoid carcinoma, ruled out possibility of its originating in ribs or tissues about site of injury. One of writers (W. B. C.), testifying as expert for plaintiff, expressed opinion that all clinical facts of case, pointed to tumor being primary at site of injury, not at root of lung; he believed tumor at root of lung to be metastatic from tumor at site of injury. This clinical evidence, he believed, outweighted that based solely on the histological type of tumor, for the reason that tumors of the lung are recognized as extremely difficult to classify exactly, some pathologists calling a case epidermoid carcinoma and other endothelioma. Verdict of third referee in favor of defendant.

Fourth trial: Plea to have case reopened granted by Hon. Frances Perkins, now U. S. Secretary of Labor, who had succeeded referee who made last decision. Case again heard in fall of 1927, and in July, 1928, final verdict was rendered by Commissioner Perkins in favor of plaintiff, reversing the previous decisions. A copy of her decision may be of interest:

"Because the question of fact in this case was considered to be extremely close, the record has been personally reviewed by four members of the Board, each reading independently and writing a memorandum of decision without conference with the others. The only question involved is that of causal relation between the accidental injury and the death of L. D.

"Three members of the Board have found causal relationship to be established and one considers the weight of medical evidence to be against such a finding. The Board, therefore, finds that L. D. sustained a crushing injury to his chest wall on July 30, 1921; that the injury was serious is shown by the fact that he had difficulty in breathing and continuous pain in his chest for many weeks. In September, 1921, he had a hemorrhage and spat blood and pus. The pus when analyzed showed streptococcus and staphylococcus.

"There can be no doubt of the inflammatory condition or that it resulted from the accident. This indicates serious injury to the pleura. The case was diagnosed by his physician as traumatic pleurisy. He grew constantly worse, was in a hospital for sev-

eral months, treated for pleurisy, broncho-pneumonia, with some physicians suspecting tuberculosis. He had been a man in exceptionally good health prior to the accident but he declined rapidly. On January 11, 1922, he died, still a puzzle to the hospital physicians. An autopsy was performed and an epidermoid carcinoma was found to have involved the lungs, ribs, kidney and liver. This carcinoma is stated to be the cause of death.

"The contest has been as to whether there was a causal relationship between the injury and this cancerous growth which progressed so far as to cause death. The testimony on this point has been difficult to follow because obscured at times by antagonisms and by arguments and confused by objections, interruptions and comments by counsel for both sides to a degree at least unusual in this jurisdiction. His family physician who treated him throughout as of the opinion that death was the result of the accident. There is also other expert medical testimony to this effect.

"After long and careful consideration, the Industrial Board finds that the death resulted naturally and inevitably from the accidental injury."

In reporting this case (see 1929 Year Book, New York and New England Association of Railway Surgeons) Doctor Coley cited two other cases in which very similar verdicts had been rendered by the Supreme Court.* In the first, the referee ruled that "compensation is payable where death occurs within 300 weeks of the time of the accident, provided the testimony shows it was caused by the injury, or, by reason thereof, an incipient condition was hastened to development, ending in the loss."

In the second case it was ruled that "claimants'" right to recover compensation is controlled by section 2 subdivision (d), of the Workman's Compensation Act (Law 1918, c. 400), which is as follows:

"'Injury' and 'personal injury' shall mean only injury by accident arising out of and in the course of the employment and shall not include a disease in any form, except where it results naturally and unavoidably from the accident. . . .

"It is conceded that if there is evidence to sustain the finding that the sarcoma resulted from the alleged injury, or if it was at the time of the accident in a quiescent state and the accident aggravated it and hastened the employee's death, then the requirements of the above-quoted section are met and the present claimants are entitled to compensation."

The referee continued as follows:

"Whatever view we take of the medical opinion, they are frankly and at best but theories, but taking them as they are in connection with the facts heretofore narrated and taking a common-sense, practical view, as courts and commissions must take of the ordinary happenings of life boiled down to its last analysis, the medical theory is that there is a relationship between the receipt of injury and orgin of sarcoma, and that the degree of injury plays no important part. With this in mind we find a perfectly healthy, strong man, who has never lost any time from work or complained of any illness, suffers an injury and from that time on is incapacitated, grows worse and worse, sarcoma develops at the point of injury, from which he dies. The lay mind, under such

* Smith *vs.* Primrose Tapestry Co., 131 Atl. Rep. 703 (285 Pa. 145), decided by the Supreme Court, Pennsylvania, January 4, 1926. Winchester Milling Corporation *et al.* V. Sencindiver *et al.* 138 S. E. Rep. 479, Supreme Court of Appeals of Virginia. June 16, 1927.

circumstances, can reach no other conclusion than that reached by the commission, *viz.*, that the sarcoma was either caused by the injury or was aggravated by it. . . .

"To this we may add that the courts have in general found no difficulty in cases similar to the one we are considering here, in applying the ordinary rules of evidence, and in drawing the ordinary conclusions of cause and effect from established facts, and we find none. This, we doubt not, courts will continue to do with a full sense of justification and without apology until the cause of cancer is definitely and scientifically established."

In the following case of intra-abdominal sarcoma following a recent trauma the evidence of a causal relationship appears to be convincing.

CASE V.—R. T., male, aged thirty-four years, had always been in good health until July 3, 1916, when he fell from a building for a distance of eighteen feet striking on a cement floor; he landed in such a position that his upper abdomen received a sharp blow from his doubled-up elbow. Six or seven months later he complained of pain in the upper left abdomen at the site of the injury. He consulted a number of physicians and surgeons who made various diagnosis. In December, 1917, he came under the care of Doctor Charles H. Mayo, who made a clinical diagnosis of lymphosarcoma of the small intestine. He performed an exploratory operation which revealed a large, inoperable tumor of the mesentery and small intestine, largely posterior to the parietal peritoneum. Deeming a surgical removal unwise, Doctor Mayo referred the patient to us for conservative treatment. Under irradiation and toxins the tumor practically disappeared, and the disease was held under control for five or six years at the end of which time metastases developed in the neck and axilla. Under further treatment the disease was again controlled. At the end of nine years the patient had a recurrence of the original tumor and died in a few months. The microscopical diagnosis in this case was lymphosarcoma. Autopsy was performed, and the only tumor found in the entire body was at the site of the original tumor.

Trauma and Its Relationship to Tumors of the Testicle.—Most writers on tumors of the testicle, having observed a large number of cases in which there was a history of antecedent local trauma, have come to the conclusion that there is a causal relationship between trauma and tumor formation. Dew,[18] in his book on "Malignant Disease of the Testicle," states:

"The testicle from its exposed situation is particularly prone to traumatic insults, and as it is peculiarly sensitive these are often keenly remembered, yet neoplasms of the testicle are quite rare. Still even bearing in mind the very human tendency which seeks to attribute disease to a definite cause such as injury, all statistics go to show that, in this organ, trauma is an important factor, and most writers on the subject emphasize its importance.

"In a carefully recorded series Howard[19] found that eight cases out of twenty-seven gave a history of recent trauma and in another case there was a history of trauma some time before. Miyata,[20] out of twenty cases, found trauma a factor in ten. Sehaguchi reported four out of thirty-two to give a definite history of injury. O'Crowley[21] reported six cases out of a series of thirteen. In the present series I have found that out of the thirty-three of which clinical notes are available, twelve gave a history of more or less recent trauma.

"Practically all observers give similar figures. . . .

"It is extremely difficult to be sure that a definite essential connexion between tumour formation and trauma does exist, but the figures strongly favour that belief. It is well known that, experimentally, trauma has the power of exciting spontaneous growth in ova

parthenogenetically and it may be that investigation along these lines will provide an explanation.

"There is no doubt that the opinion of experienced observers may be summed up by stating that there is a definite history of trauma in anything up to 50 per cent. of these tumours, though definite causal relationship still remains to be proved."

According to Öphuls, carcinoma of the testicle is the only type of carcinoma which is frequently caused by a single, more or less severe injury. He states: "This includes the so-called round-celled sarcoma of this organ, because careful histological examination reveals that most of these so-called sarcomata arise from the epithelium of the seminiferous tubules, and therefore should be classified as carcinomata. The frequency of their traumatic origin, to my mind, has not been sufficiently emphasized; but anyone who has had experience with these growths will readily confirm it from personal experience, and a study of the case reports collected in literature reveals the same thing. When we consider the constant and very active multiplication of the spermatogenous cells under normal conditions, we may readily understand why a thorough, even single disturbance of them may lead to such disastrous consequences. The mere fact that these growths are usually encountered in comparatively young individuals, in the prime of sexual activity, lends strong support to this theory. . . . It would appear, then, that in estimating the probability of a connection between trauma and the development of a true tumor, the collective experience so far obtained in the particular type of tumor concerned should also be carefully taken into account."

In a monograph on "Malignancy of the Testis, with Special Reference to Undescended Testis" (Minneapolis Surgical Society Prize Winning Essay for 1930), Rea[22] reports seventy-six cases of malignant tumor of the testis. In discussing etiology, Rea[22] states: "Twenty-nine of the patients (38 per cent.) gave a history of some variety of trauma preceding the recognition of the tumor, but the information in the records is of such a character as to leave much doubt as to whether the trauma had actually any significance in the development of the lesion or whether it served merely to call attention to a pre-existing tumor."

Kober[23] found a history of trauma in 28 per cent. of 114 cases.

One of the writers (W. B. C.), in a study of sixty-four cases of sarcoma of the testis personally observed up to 1914, found a definite history of antecedent trauma in 33 per cent.

Melanotic Sarcoma.—While the majority of melanomas or melanotic sarcomas have their origin in a pigmented mole, the transformation of the latter into a malignant tumor is usually associated with repeated trauma or repeated irritation, for example, friction from clothing or from a bath-towel. Many cases, however, give a history of a single local trauma, such as, tying off a pigmented mole with a silk ligature, the use of cautery or some form of caustic. One striking example in our experience of a melanoma developing from a single trauma occurred in an Army man who, in 1917, received a typhoid inoculation through a small pigmented mole in the deltoid region. This had existed since childhood. Within a few weeks the mole showed evidence of increasing activity; it grew rapidly in size, and in spite of a surgical removal, the disease metastasized to the glands proving fatal in less than a year.

Neurogenic Sarcoma.—The statement has been made at medico-legal trials that neurogenic sarcoma is practically never associated with antecedent trauma. This has not been borne out by our personal experience. We have

observed a number of cases of neurogenic sarcoma in which there was a very definite history of local trauma. For example, a woman while travelling on an ocean liner was struck in the middle of the forearm by the heavy wooden cover of a wash bowl. There was a definite bruise but no swelling at the time. A few months later, a swelling developed at the exact site of the injury. A local removal was made, followed later by an intrascapulo-thoracic amputation. The disease metastasized to the lung, proving fatal within a year.

An analysis of seventy-two cases of neurogenic sarcoma by Quick and Cutler[24] shows a history of trauma in fourteen, or 19.3 per cent.

CONCLUSIONS.—A careful study of our own series of cases personally observed, we believe, warrants the following conclusions:

(1) That a single local trauma may be an important factor, probably the determining factor, in the development of malignant tumors of all types.

(2) That trauma is a causative factor in a larger proportion of cases of sarcoma than carcinoma, and in a larger proportion of bone sarcomas than soft-part sarcomas.

(3) That the interval of time elapsing between the injury and the appearance of the tumor is often much shorter than is recognized by most writers. In the majority of cases the tumor develops within the first month or six weeks of the injury but in a considerable number of cases it may develop within one or two weeks. The latter cases justify the classification of *acute traumatic malignancy* originally suggested by the English surgeons. The examples herein reported furnish convincing evidence of the actuality of such a condition.

(4) While courts and compensation bureaus both in this country and in Europe have very generally recognized single trauma as a competent producing cause of all types of malignant tumors, it is only fair to the insurance carriers that each case be studied and judged on its own merits.

(5) If the case in question fulfills all the conditions laid down by Segond then a causal relationship between the injury and the tumor must be admitted.

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