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The Classic

The Bulkley Lecture: The Modern Attitude Toward Traumatic Cancer

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Abstract This Classic Article is a reprint of the original work by J. Ewing, The Bulkley Lecture: The Modern Attitude Toward Traumatic Cancer. An accompanying biographical sketch of J. Ewing is available at DOI 10.1007/s11999-011-2234-y. The Classic Article is ©1935 and is reprinted courtesy of the New York Academy of Medicine from Ewing J. The Bulkley Lecture: The Modern Attitude Toward Traumatic Cancer*. *Bull N Y Acad Med.* 1935;11:281–333.

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Many recent and fundamental contributions on the causation of tumors have an important bearing on the relation of trauma to cancer. When nothing definite was known about the effective exciting factors in mammary cancer it was permissible to adopt the traumatic theory in cases in which the clinical evidence pointed strongly that way. Now that we know that mammary cancer in mice can be produced by overstimulation by folliculin, whereas no one has succeeded in producing this disease by trauma, the traumatic origin becomes much less acceptable. Experimental cancer has now been produced by many agents, but always under quite specific conditions, not related to trauma, and these experimental data reveal the fact that cancer genesis requires quite peculiar factors which have not been found in the results of simple trauma.

The newer revelations regarding the physiological significance of tumors cannot fail to modify views concerning the possible relation to simple trauma. At one time it seemed necessary to assume that many cases of giant cell tumor of bone resulted from injury, but since it has appeared that this disease is related to functional disturbance of the parathyroid gland and that giant cell tumors may be produced by hyperparathyroidism, and cured by extirpation of tumors of the parathyroid, it becomes unnecessary to introduce the idea of trauma into the etiology of giant cell tumors. The application of dibenzathracene in experimental animals produces cancer and sarcoma promptly and almost invariably, whereas the innumerable efforts to cause tumors by simple trauma have always failed. This contrast cannot fail to impress thoughtful observers with the impression that when we deal with real cancerigenic agents the results are definite, positive and even startling, and that the negative results of trauma indicate that trauma does not possess the essential elements of a cancerigenic agent. Knox has reviewed many of the old and recent efforts to produce tumors by trauma, all of which have failed.

These and many other contributions of the past two decades have greatly widened the breach between the real causation of malignant tumors and the theory of trauma, and these new facts must be fully considered in forming opinions regarding the traumatic origin of any given tumor. However, the new facts do not warrant one in excluding trauma as a possible cause of many tumors. The clinical

evidence is too substantial in many cases to be dismissed on theoretic grounds. Recent knowledge merely demands that the evidence favoring trauma must be scrutinized more closely and great importance must be given to other factors which are more in line with the known effective exciting causes of neoplasms.

While it is now generally agreed that a single trauma never produces a malignant tumor in previously normal tissue, this principle may not greatly reduce the medico-legal importance of injury as an indirect cause of tumors. When a lacerated wound of the skin with implantation of foreign material fails to heal, becomes infected and suppurates for weeks or months, and cancer finally appears in the edges, it is clear that the cancer would not have occurred without the trauma.

The essential characters of medico-legal evidence

One of the chief difficulties in the estimation of the frequency of traumatic cancer is the uncertainty of the statements of interested patients. Juries and compensation courts may accept the statements of claimants at face value, but medical science cannot indulge sympathies or make loose assumptions. To have medico-legal value, the statements of claimants must be supported by circumstantial evidence. Even the assertions of eye-witnesses, which have a certain corroborative value, cannot be accepted as facts unless supported by circumstantial evidence. There have been many striking instances where the positive assertions of several eye-witnesses were proven wrong by circumstantial evidence which was inconsistent with such statements. For example, a man was seen by several near-by persons to run out of a saloon, followed immediately by an assailant who stabbed the victim in the back with a knife. The assailant was tried for murder, but acquitted because the autopsy disclosed that the victim had died of a deep wound of the liver, and delivered from in front, while the observed knife wound had barely penetrated the skin of the back.

Therefore, all statements of claimants and eye-witnesses, regarding accidents should be supported by concrete evidence, readily verifiable, and relating to the locality of the accident, the objects alleged to have been concerned, and the possibility of the occurrence of the injury described by the claimant. If such necessary evidence were secured, the reports of traumatic cancer in the literature would be enormously reduced.

Without attributing any deliberate intention of any claimant to falsify the facts, every student of psychology knows that the human mind is strongly influenced by preconceived notions and by self interest. The wish is father to the thought. By repeatedly asserting facts of which the individual is at first uncertain, it is possible to render the mind entirely convinced of the reality of incidents that have not occurred in fact. At any rate, for scientific purposes, these laws of psychology must be regarded in all inquiries concerned with the traumatic origin of tumors. When the patient's doctor, on whom the patient's life may depend, begins an inquiry by displaying an obvious interest in establishing a traumatic history, the patient invariably responds with a vivid imagination, and the doctor himself becomes a victim of his own efforts. Even the most judicially trained minds are not free from this subtle influence. When the U. S. Supreme Court, in 1876, was called upon to decide whether Samuel J. Tilden or Rutherford B. Hayes had been elected president, the evidence consisted of certain verifiable facts, but the four Republican members voted in favor of Hayes, and the three Democratic members voted for Tilden.

Having investigated many cases in which the statements of patient and friends clearly indicated a traumatic origin of a tumor, only to find that these statements were unreliable, I have become convinced that the chief task of the medico-legal expert is not one of theoretical reasoning and argument, but almost entirely that of laborious fact-finding. It requires time, patience and ingenuity to establish the facts in cases of alleged traumatic tumors, and unless these efforts are competently made, the report of any given case is, for scientific purposes, worthless.

> An intelligent young woman, free from any thought of compensation, presented herself at the Memorial Hospital with the following history. In August, 1934, she stated that she had fallen out of a swing and struck violently on a gravel bed bruising the palm (but not the wrist?) of her right hand. She paid little attention to the incident. One month later she noticed that the fingers of the hand were contracting, and this condition became steadily worse until November, when she went to an orthopedic hospital where a pronounced Dupuytren's contraction was found, with marked nodular thickening of the whole palm. The palmar fascia was then liberally excised. The material showed, on section, a cellular neurogenic fibrosarcoma of considerable malignancy, tumor cells infiltrating the nerve trunks throughout. She stated that before the accident the hand was entirely normal, because she was able to use the typewriter as her occupation, without difficulty. Here was a most circumstantial and convincing story pointing clearly to a traumatic neurogenic fibrosarcoma. (1)—The previous integrity of the tissues was adequately shown by the lack of interference in using the typewriter. (2)—The authenticity of the trauma was well established by the violent fall under unusual conditions,

which she stated was witnessed by three friends. (3)—The nature, probable age, and active growth of the tumor completely coincided with the story.

However, it was determined to make a systematic effort to break down the facts in the story, and two physicians devoted several hours to the task. It required three interviews to prove that the swing story was a fiction. To one interrogator she failed to mention the swing and referred the trouble to overuse of the broom. She had just been separated from her husband and he could not be found. Her brother-in-law was in camp in Canada (December 15?), and could not be reached, and her sister-in-law (who should have been her sister) was with him. Thus none of the alleged witnesses could be reached. She finally admitted that she had not used the typewriter for three years. A review of new sections from other parts of the tumor material revealed much old hyaline fibrous tissue, completely devoid of cells which must have existed much longer than the three months alleged duration of the tumor.

The probability of coincidence of trauma and cancer

Assuming that every tumor that arises after trauma is of traumatic origin, the incidence of traumatic tumors still remains extremely low. In the records of the New York State Industrial Compensation Bureau, Lewy found 37 cases of malignant tumors among 26,389 injured persons. In few of these cases could the traumatic origin be established as reasonable. This ratio is about the normal incidence of tumors among the general population. Some French medico-legal experts report the occurrence of as low as five or six traumatic tumors among 100,000 injuries. Many authors have remarked upon the very small number of traumatic tumors observed during the GreatWar (Knox Lit.). According to von Bungener (Cit. by Ullmann), in all the German University clinics, during a long period of observation, not more than 100 certified traumatic tumors have been recorded. From these data one must conclude that trauma itself has generally very little tendency to produce malignant reactions in tissues and when it does so the conditions must be peculiar.

Not only those persons who develop supposedly traumatic tumors, but all classes of the population, especially young persons and artisans, are constantly exposed to injuries mild and substantial to which they pay no attention. The National Safety Council reports that in the United States there were in 1933, 8,730,000 disabling injuries. There must have been many more of milder type to which tumors are generally referred. The skin, the bones, and the female breast are especially exposed to such injuries. There is thus established a strong probability that by mere coincidence any portion of the body which develops a tumor has within a recent date received some blow. Yet this argument loses some force when it appears that the tumor develops shortly after an unusual injury and at the exact point injured.

The probability of coincidence becomes more clearly revealed when one considers the time factor in the development of cancer. Cancer does not develop suddenly. The precancerous changes leading to cancer cover a period of months and sometimes years before the signs of established disease appear. During all this time the tissues are exposed to the usual traumas, mild and severe, to which the average person in active life is subjected. If at any time during this long period a trauma occurs at the site of the precancerous lesion, the subsequent cancer may erroneously be attributed to the trauma, whereas it is in reality the inevitable result of the progress of precancerous changes which have nothing to do with the trauma.

The coincidence of two very rare events raises a presumption but does not prove that there must be a causal relation between them.

> A man fell backward on a cellar floor fracturing the spinous process of the 7″ cervical vertebra. Two months later he complained of a nodular thickening along the brachial plexus and marked atrophy of the muscles of the hand. A slowly growing fibrosarcoma of the brachial plexus was disclosed, running a course of three years. The previous history could not be established, but it is reasonably certain that the tumor antedated the injury which was limited exactly to the spinous process, with normal healing. Here the coincidence of two rare events seems to create a presumption of a causal relation. A positive opinion could not be given because of imperfect fact-finding, especially regarding the previous condition of the patient, the immediate neurological effects of the injury, and the exact date of appearance of the atrophy.
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> A child was run over by an automobile, the wheel passing over the pelvis. It was taken immediately to a hospital, and operated upon for hematuria. A Wilms' tumor of the kidney was found. Such incidents show that rare tumors and peculiar accidents may coincide.

All these considerations justify the attitude of medico-legal experts, who refuse to regard a history of previous trauma as an adequate explanation of any given tumor, and who insist in subjecting the evidence to close scrutiny in each case, and who are inclined to give superior weight to the presence of other well known and adequate causes. Accordingly, several definite criteria have been widely recognized as essential conditions for the acceptance of a traumatic origin of a tumor.

Essential Criteria

The authenticity and adequacy of the trauma

The fact that an injury actually occurred is generally accepted on the statement of the patient, but while such evidence may be accepted by the courts, it must be regarded as inadequate for strictly scientific purposes for reasons previously explained. Such evidence must be corroborated by eye-witnesses or better by circumstantial evidence such as the immediate discovery of signs of injury by an intelligent layman or a physician. In many instances only competent medical examination is worthy of credence. In the absence of corroboration the circumstances of the injury should be carefully investigated, the nature of the terrain, the actual existence of objects alleged to have been concerned, the exact sequence of events, and the possibility that the incidents described could have occurred or have resulted in the alleged injury. Many a case falls down when a simple orderly inquiry of this sort is pursued.

The exclusion of previous injuries of the same sort is necessary, otherwise the condition amounts to chronic irritation and not trauma in the strict sense. Shop women frequently bump their breasts in pulling out rolls of goods. Hod carriers constantly bruise their shoulders by the weight of the hod. Many persons repeatedly strike shin, or hip, or shoulder, against projecting objects to which they are daily exposed. Machine operators frequently strain or bruise certain tissues which are especially exposed in their particular occupations. Tumors which arise under such circumstances are more properly regarded as occupational diseases than traumatic tumors.

The trauma must be adequate to produce some alteration in the structure of the tissue and the least effect it can give is rupture of small blood vessels with hemorrhage and discoloration of the skin. It should also be capable of exciting some regenerative process, otherwise it is difficult to conceive how it can excite excessive and abnormal proliferation of cells.

Much importance attaches to the character of the wound, and of the instrument causing it. Clean surgical incisions never lead to cancer. The presence of retained blood clot or fragments of necrosing tissue provide conditions in which abnormal reactions may conceivably occur. When foreign bodies or irritating chemicals, such as acids, tar, wood, etc., are carried into a wound, healing is delayed and atypical results may be expected. There are many reports of cancer of the skin following wounds of this character. No doubt many of these are coincidences, while others represent the combined result of injury and previous alteration of the skin. In all such cases one must inquire whether the patient has been exposed to tar, or petroleum products, or has had a course of arsenic therapy, or suffers from multiple keratoses.

The previous integrity of the wounded part

While courts and juries may accept the patient's statement that the injured tissue was previously entirely normal, the positive demonstration that a tumor is of traumatic origin requires proof rather than assumption. Most patients who develop cancer assert rightly that they had been in excellent health. The majority of cancer patients connect the beginning of trouble with trivial incidents, the most satisfying of which is an injury. Very often the occurrence of an injury, mild or temporarily disabling, combined with the recognition of a serious disease, with doctor's visits, interrupts the patient's routine, and enables him to state truthfully that he "was well before the accident and continuously sick thereafter." Usually the only proof of previous integrity is the evidence of competent medical examination. Adherence to this criterion would exclude many of the cases of supposed traumatic cancer.

The incidence of cancer is sufficiently high to justify the pathologist in conceiving of normal tissues, not as normal but as harboring a great variety of structural abnormalities, tissue rests, precancerous lesions and even miniature cancers. Moore finds that the prostate in 16 per cent of subjects between 20 and 90 years of age shows miniature cancers, while between 45 and 90 years the proportion is 29 per cent. The presence of marked cystic disease in one breast raises a presumption that a cancer in the other breast arose on a basis of cystic disease. Many cases of supposed traumatic sarcoma of bones are rejected when an immediate radiograph shows that a tumor was well established at the time of the injury. The presence of multiple small tumors in elderly subjects seems to increase in direct proportion to the industry of the pathologist in searching for them. So strong is the evidence against the purely traumatic origin of most cancers that one must assume the attitude that a supposed traumatic cancer arises not in normal but in previously altered tissues. Trauma reveals more malignant tumors than it causes.

Traumatic determinism

The presence of an unsuspected tumor tends to bring about the occurrence of injuries at the tumor bearing area and to intensify the subjective symptoms and local effects of injury. This principle may be designated as traumatic determinism.

> A man is found at the bottom of a stairs unconscious and with a hematoma of the scalp. He recovers but complains of headache and attacks of vertigo. After three months, the symptoms persisting, an operation discloses a slowly growing glioma of the brain, exactly beneath the hematoma. It then transpires that

he had suffered from attacks of vertigo for some months before the accident. In one of these he became unconscious and fell down stairs.

A carpenter slipped down a ladder and bruised his shin. Pain continuing, two weeks later a radiograph showed a sclerosing osteogenic sarcoma occupying the upper end of the tibia. The leg was immediately amputated, but pulmonary metastases had occurred and proved fatal. It was then attested that he had been noticed to limp and spare the limb for some weeks before the accident. It is evident that the tumor antedated the accident and interfered with the normal mobility of the knee joint.

A young woman fell down the subway steps and injured her knee cap. She continued working as usual for two months when pain set in and she was treated for traumatic arthritis for two months. Radiographs then disclosed a large tumor of the lower end of femur, many small cysts in the patella, several cysts in the upper ends of both femora, pubes, and lumbar vertebrae and pronounced scoliosis of the dorsal spine. The leg was amputated and a benign giant cell tumor occupying much of both condyles was found. The structure was fibrous, and therefore, of slow growth. Here the tumor of the femur antedated the accident, and the general signs of osteitis fibrosa cystica showed that she was suffering from Recklinghausen's disease with complicating giant cell tumor. The marked disease in both patella and femur satisfactorily accounts for the accident which occurred, without other adequate explanation.

With cancer of breast, tumors of testis, cancer of sigmoid, neurofibromas of superficial nerve trunks, and many others, the local conditions produced by the tumor include increase in bulk, fixation in the organ, adherence to skin and deep structures and often some inflammatory reaction. All these conditions tend to convert many simple blows, pressures, stretchings, etc., into forces capable of injuring the tissues with pain and hemorrhage, whereas in normal tissues the effects would have been nil. It is in this manner that injury usually brings to light unsuspected tumors. Whenever an apparently trivial injury is said to have produced some peculiar and exaggerated effect, and a tumor is later discovered, it should raise the suspicion that the tumor antedated the injury.

The tumor must arise at the point of the injury

Any reasonable theory of the traumatic origin of a tumor must assume that the tumor develops in tissues actually altered in structure by the trauma and not from some mild transmitted force leading to intangible nutritional disturbances of which we know nothing. Such alteration in structure can only be produced at the exact point of the injury or within narrow limits. A blow on the knee cannot be assumed to be connected with a tumor arising in the hip, and an injury of the nipple cannot be responsible for a cancer arising in the upper outer quadrant of the breast. Lesions limited to the skin may not necessarily affect tissues deep beneath the skin.

On the other hand, there may be severe injury to deep organs without obvious damage to the skin, but the extent to which such deep effects may be expected will depend on many circumstances and becomes a matter of careful clinical judgment. In skull injuries the principle of contrecoup is of importance but difficult to evaluate. I have not found evidence that injuries to the cranium have been connected with epithelial tumors of the sinuses or nares.

Without obvious damage to the skin serious injuries may be produced in abdominal organs, such as rupture of liver, spleen and stomach. This result may be referred to the mobility of the abdominal skin and the fixation of liver and spleen. Much less frequently a movable organ as the stomach and intestine may be injured without obvious injury to the skin. When both skin and deeper injured tissue are fixed, the assumption that the deep tissue alone may be damaged must be regarded with much caution.

When the body falls from a considerable height and is subjected to general mechanical violence, the way is open for the assumption that a tumor in any organ may result, but unless there are definite symptoms pointing to injury of the organ there is no ground for such an assumption. It is difficult to conceive how a general concussion of the body can give rise to a malignant tumor at a particular point in which no structural damage can be demonstrated.

A reasonable time limit must be observed between the injury and the appearance of the tumor

It is difficult to establish any definite limits within which a tumor may reasonably be ascribed to trauma. Presumably the malignant process may represent a part of the original but generally somewhat delayed healing reaction, and thus appear within a few weeks. With very rare exceptions there is an interval of three to four weeks or more, before there is any definite sign of a tumor. According to Sauerbruch the interval for sarcoma should not be under three weeks, while for carcinoma, it may be as long as ten or twenty years. The absence of such an interval strongly indicates that the tumor antedated the injury. Some of the acute traumatic bone sarcomas appear very soon after injury, but nearly always after a certain interval. I have seen several cases regarded as sarcoma within two weeks after injury, but which proved to be myositis ossificans or benign exuberant callus. The histological structure of injured tissues following football injuries is notoriously difficult to

distinguish from sarcoma and many limbs have been unnecessarily amputated for this reason.

The type of the tumor often decides whether it could possibly have grown in the particular time period. Again, the malignant process may be presumed to result at a late period, months or years, after the injury, from the disturbance caused by scarring and interference with function and nutrition. Yet the passage of time allows the entrance of many other factors into the causation, so that the longer the interval the less certainly may the tumor be referred to trauma. Here again the type of the tumor is often of decisive importance.

Continuity of Symptoms

The so-called bridging symptoms, between the injury and the appearance of the tumor are of interest and occasionally of importance. When the evidence shows that a wound of an apparently normal tissue never healed, that pain, swelling and discharge persisted for weeks and until the definite appearance of a malignant process, then one must accept a presumption in favor of the traumatic origin, and rely upon other features if the traumatic theory is to be rejected. Yet when dealing with tumors of the internal organs I have not found that bridging symptoms are of real significance, because it is well known that the first symptoms of cancer of the stomach, lung, etc., frequently appear suddenly and that they are invariably referred by the patient to some incident, often trivial, and almost, always to injury if trauma of any sort has occurred within the memory of the patient. These considerations apply also to the question of aggravation. Several German authors have pointed out the unreliability of bridging symptoms. When an unsuspected tumor is injured the symptoms are apt to be out of proportion to the injury and to continue until the presence of the tumor is recognized, whereas when normal tissues are injured they generally heal normally and a symptomless interval separates the injury from the signs of tumor.

The positive diagnosis of the presence and nature of the tumor is essential

This criterion will be obvious to all who are familiar with the uncertainties of the clinical diagnosis of tumors. Troell reviewed 105 cases registered as bone sarcoma in the Stockholm hospitals, and found that one in four was not sarcoma. The complete modern diagnosis of structure, grade of malignancy, origin and probable course of malignant tumors furnishes information essential in medico-legal interpretations. Biopsies and autopsies should therefore be made mandatory. Microscopic examination often reveals that a supposed primary tumor is tuberculosis, or syphilis, or lymphogranuloma or some form of metastatic carcinoma. It may show that the tumor is a slowly growing process which antedated the injury. Histogenetic diagnosis should replace the simple histological report, for there is a wide difference in the medico-legal relations of spindle cell osteogenic sarcoma and neurogenic sarcoma, between lymphosarcoma, lymphoepithelioma, and round cell carcinoma, and between many other varieties of tumors, but these important distinctions are seldom recognized in current medico-legal reports.

The tumor must be of a type which can reasonably be referred to trauma and which is consistent with all the facts in the case. Judgments in this field must be based on a broad knowledge of the causes, natural history, and structural features of the different forms of tumors.

To be the result of injury a tumor must be of a type which can be referred to disordered processes of regeneration in any injured tissue. One cannot refer a cancer in bone to bone injury, because there is no possible source of such a tumor in bone. Yet adamantinoma of the tibia, etc., has sometimes been traced to the traumatic transfer of a fragment of epidermis and epidermal glands into the underlying bone.

The traumatic theory is applied with difficulty to the entire group of tumors arising from tissue rests. There has never been any evidence adduced to show that these rests are incited to growth by local injury, although Ribbert was willing to consider such a possibility. Accordingly, one must exclude from the field of trauma such tumors as adrenal rest and other peculiar tumors of the kidney, mixed tumors of the salivary glands in various locations, branchiogenic carcinoma of neck, myoma uteri, aberrant thyroid tumors, myomas and myosarcoma of the gastrointestinal tract, and the entire group of complex tumors of the cephalic and caudal extremities of children.

Likewise local teratoids, or mixed tumors, such as fibroadenoma of breast, and its variants, carcinoids of appendix, adamantinomas of jaw, and many complex neurogenic tumors must be excluded from the traumatic class. A highly embryonal cell character is very difficult to reconcile with an origin from trauma, and can reasonably be referred only to an embryonal character of the cells of origin.

A review of reports of alleged traumatic tumors in several languages leaves the impression that legal medicine is struggling along in many countries with very meagre aid from exact tumor pathology. Industrial surgeons and most pathologists are not much concerned with the relation between tumor structure, histogenesis, rate of growth and possible behavior of neoplasms. Many cases, obscure in all other respects, could be readily decided by reference to this source of decisive information.

Thus, two well-known authors, in an otherwise astute contribution, report some of their cases as "sarcoma" and "carcinoma." They ask one to believe that an epidermoid carcinoma can arise and destroy the whole body of the mandible for two inches and extensively invade the cervical nodes in 3½ months.

Aggravation

The theory of aggravation of an existing tumor has assumed much importance in compensation courts. The object of the law granting awards for aggravation of a tumor seems reasonable if the course of the disease and its fatal termination are definitely hastened, or if trauma introduces into the course of the malady features and complications, injurious to the well-being of the patient, which do not normally belong to the disease. It can hardly be assumed that the law intended to insure workers against the occurrence and natural symptoms of all malignant tumors which arise from causes not connected with industry.

One must consider, first what constitutes aggravation. An injury which hastens the death of the patient must be accepted as aggravation. Such results are seen when a trauma causes immediate hemorrhage, infection, and collapse in advanced cases of cancer of stomach, or other internal organs, or when a fracture is precipitated in a bone which is the seat of a sarcoma, with subsequent severe hemorrhage and infection. When, however, the trauma merely leads, somewhat prematurely, to complications which are inevitable in the course of the disease and are about to occur in the normal course, it seems inequitable to assume that any aggravation has occurred. The normal course of the malady has not thereby been altered. The small hemorrhages of gastric and other internal cancers, the initial attacks of pain in sarcoma, the erosion of superficial ulcers, the infarction of bulky tumor masses, the sloughing of infected tumors, the sudden closure of hollow viscera, and many other events are natural features in the course of the diseases, are often the initial symptoms of the diseases, and cannot be regarded as aggravation. All these incidents are bound to occur in the ordinary environment of the patient, and they frequently appear when the patient is lying in bed, or walking up stairs, or straining at stool, or suffering from bad news. Unless the trauma introduces into the course of the disease, something which does not belong there and which works to the disadvantage of the patient, aggravation may not properly be assumed.

Trauma may cause temporary complications in the course of a tumor, the effects of which disappear in due time, and have no permanent influence on the total course of the disease. Thus a patient with unsuspected carcinoma of the lung, falls into a ditch and breaks his arm which heals after six weeks. He dies a year later from the carcinoma of lung which runs an average course. He should receive compensation for the fracture, but not for the carcinoma. A woman with generalized carcinoma of the breast with metastases in many bones is shaken up in a collision of a public conveyance, and has to remain in bed for a month, after which the malignant disease runs its natural course. Here there is no definite ground for assuming aggravation of the cancer.

When injury discloses the presence of a tumor and leads to earlier operation, which may be the best method of treatment, the chances of recovery are improved and aggravation may not be assumed.

It is generally assumed that trauma may activate a latent cancer and increase the growth energy of the cells, but the grounds for this view are unsatisfactory. It is very doubtful if any primary cancer is ever in a state of quiescence, although the early growth may be slow. The idea that trauma may endow the cells with greater powers of growth must be rejected. The growth energy of tumor cells is determined by the conditions of origin, although its manifestation may vary with the environment.

Lubarsch bruised fibroadenomas of the breast in rats and epitheliomas of the dog by repeated blows of a hammer and by crushing them with a forcep, but failed to find any increase in growth or number of mitoses. In some mice with two tumors the one traumatized regressed or remained stationary, while the other grew. As a rule he found that any marked disturbance of circulation was followed by regression.

Marsh subjected malignant tumors in mice to various severe injuries and found retardation of growth as often as acceleration. When large tumors were traumatized infection and sloughing sometimes followed with the earlier death of the animal, but with smaller tumors retardation was rather more prominent than any signs of acceleration.

There are several conditions in which severe trauma must be accepted as capable of accelerating growth and hastening death. (a)—When an encapsulated tumor suffers rupture of the capsule, pressure is relieved and the tumor may grow more rapidly for a time. Whether the injury thereby hastens the total course of the disease must be judged by the general clinical picture. (b)—When trauma introduces infection, especially in superficial tumors, the course of the disease may be hastened, owing to more active proliferation of tumor cells, and probably in some cases by favoring metastases, but whether such results have actually occurred must be determined by clinical judgment, by one who is familiar with the natural course of the disease. One not infrequently sees an increased number of mitoses in cells surrounding pus foci in epidermoid carcinoma. (c)—In several thousand diagnostic punctures by

needle and trocar, I have not seen any evidence of increased local growth or metastases. Surgeons have not been deterred from the universal practice of taking biopsies, by resections often of considerable size, because of any observed increase in growth of the tumor or danger of metastases.

Wood performed many biopsies on transplanted carcinomas of mice without observing any increase in growth. Rohdenburg collected a long series of cases in which a partial removal of a tumor was followed by regression of the remainder. On the other hand the curettage or partial removal of a bone sarcoma is very apt to be followed by prompt recurrence and more rapid growth and sometimes by a definite change in the structure of the tumor, but insults on such a scale rarely occur by accident. Accordingly, one must conclude that unless a tumor has received a severe crushing injury there is no definite danger of increased growth or metastases.

In general, opinions regarding aggravation must be based on broad clinical judgment and the observation of actual facts, rather than upon the pursuit of speculative possibilities.

Can trauma cause the appearance or localization of metastatic tumors

It is surprising how many metastatic tumors are referred by the patients to some previous injury. This situation occurs so often as to suggest that the injury is in some way responsible for the metastases. It is well known that the lowered resistance and obstructed circulation of traumatized tissue may gather bacteria from the blood stream and lead to local abscesses. Burrows, in an elaborate investigation, has pointed out many interesting features of the localizing effects of injured and especially infected tissues, but he was unable to find any definite application of this doctrine in the field of cancer. Lubarsch failed entirely to localize metastases in mice with inoculated tumors by fracturing the bones.

Jones and Rous placed kieselguhr, dead tumor cells, and glass rods in the peritoneum of many mice and found much greater tendency of injected tumor cells to become implanted in the regenerating tissue about the foreign material. Since regenerating fibroblasts are more active than resting fibroblasts in tissue culture they concluded that the regenerating tissue was more apt to provide the stroma necessary for the implantation. However, implantations were not infrequent in the control animals, and it is not clear that the conditions in the peritoneum are comparable to those of injured human tissues. The evidence drawn from many experiments with chicken sarcomas, reviewed by Foulds, shows that tumor cells may be localized by various types of injury, but also by almost any structural abnormality in the tissues.

It may be conceived that the damaged capillaries in a traumatized area may sift out vagrant tumor cells, which are able to grow in the devitalized area as do bacteria, and thus that metastases may develop which might not otherwise appear. In order that any such event should occur it is necessary that tumor cell emboli should frequently be present in the circulation. Such conditions exist only in the advanced stages of malignant tumors. The chances are overwhelmingly against a single or occasional or precocious embolus lodging in a traumatized focus. The assumption that tumor cells are constantly being discharged into the circulation is not supported by any definite evidence. Tumors probably vary in this respect and it is possible that some very malignant cellular growths release numerous cell groups even in their early stages. These cells must be sifted out by the lungs. Schmidt found some indications that tumor cell emboli may be destroyed in the lungs. If by some rare chance vagrant cells did lodge in such a traumatized area, there is some reason to conclude that the conditions for growth are somewhat better than in lung or bone marrow, where metastases usually appear. I believe, therefore, that the possibility of the localization of metastases by trauma may not be excluded. However, trauma at a distance cannot dislodge the vagrant cells, and its influence would be limited to a particular localization of tumor cells which would probably produce a metastatic tumor somewhere in the body. Accordingly, one must conclude that if a trauma causes a localization of tumor cells with metastasis, this event can only occur in the late stages of the disease and at a period when the metastatic tumor cannot be regarded as influencing the course of the disease.

> Experience confirms the validity of the above principles. A laborer, who claimed to be in good health fell into a ditch and fractured the humerus. The fracture healed slowly and after four months a rapidly growing tumor appeared about the callus and other tumors appeared in the skin of the chest, axilla, and finally were noted in the lungs. A diagnosis of traumatic osteogenic sarcoma was made, but after one year the body was exhumed and a large carcinoma of the lung was disclosed with metastases in many organs and particularly in the subcutaneous tissues of chest.
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> A woman struck her head against a closet door and a few weeks later a persistent swelling appeared in the pericranium and grew rapidly. Aspiration revealed a malignant adenocarcinoma. It then was found that she had had an operation for carcinoma of the thyroid gland two years previously.

A workman struck his head against a boat hook sustaining a mild bruise without bleeding and no attention was paid to the incident. Some weeks later a rapidly growing tumor appeared which proved to be a malignant adenocarcinoma. General radiographs disclosed a tumor of the kidney and many metastases in the ribs and pelvis.

A carpenter stated that he had bruised his chest against an alarm clock, but without any laceration or ecchymosis. A few weeks later a rapidly growing adenocarcinoma fungated through the bone and skin. Examination disclosed a large tumor of the kidney with many metastases in lungs and skeleton. In all these cases the metastatic tumor probably existed before the injury and in only the fracture case was the injury authentic or adequate.

The following case suggests the localization of metastases in tissues receiving hypodermic injections. In June, 1933, a physician came to the Memorial Hospital with an embryonal carcinoma of the testis and epigastric metastases. The abdominal mass disappeared under radiation, but in October, radiographs showed pulmonary metastases, which also disappeared under radiation. In November, he developed severe headache and hemiplegia, and he was given several hypodermic injections in the deltoid region. Under radiation he recovered from the hemiplegia and was able to return to his home, but died in December with another cerebral attack. Two weeks after the injections a nodular swelling developed in the subcutaneous tissue in the area of the injections. Autopsy disclosed tumor masses only in the brain and in the deltoid region, showing the structure of the testicular growth.

Trauma as a precipitating factor in the causation of cancer

The great rarity of authentic cases of traumatic cancer, the uniform failure to produce the disease experimentally by simple trauma, and the highly specific nature of known cancerigenic agents, have led pathologists to conclude that a single trauma is itself incapable of producing a malignant tumor, and that it must always act in combination with equally or more important factors. What are these associated factors?

In mice rendered highly susceptible by selective breeding, Slye noted the frequent incidence of cancer after trauma, but no such conditions of susceptibility exist with man.

The incidence of tumors of the breast, nerve trunks and bones reveals a certain hereditary tendency. While an exalted state of hereditary predisposition may theoretically render these organs more susceptible to traumatic cancer and sarcoma, I have never been able to detect any such influence in medico-legal cases. With chicken sarcoma the exciting or growth agent unites by a special affinity with muscle tissues (Murphy) and when the muscle is traumatized a tumor develops at the injured point. But in human pathology there is no known parallel with chicken sarcoma. When the heavily tarred skin of rabbits is scarified multiple tumor nodules may appear after a variable interval in the scarified lines. Apparently the trauma precipitates the development of cancer in tissues which are on the point of yielding them spontaneously.

To a considerable extent the application of this doctrine is exemplified in the human subject, since it is well known that injuries of many kinds, especially if repeated, cause the appearance of cancer in x-ray dermatitis, or in scars of heat burns, or in simple chronic ulcers. It seems reasonable to conclude that in this field one finds the real explanation of many apparently traumatic cancers, which arise in tissues long prepared by some previous injury or irritation, with or without recognizable precancerous changes. In the case of aniline cancer of the bladder the exposure may have occurred many years before. Since in all such conditions the occurrence of cancer is very frequent, the question arises whether the cancer is chiefly due to the injury or is merely the natural expression of the original disease. The decision becomes a matter of careful clinical judgment, and in certain cases the trauma will be accepted as the precipitating cause. Such conditions call for the recognition by the Courts of a form of partial liability.

It is widely assumed that trauma may hasten the progress of various precancerous lesions, such as chronic mastitis, keratoses, benign tumors. Such a theory is possibly correct, but the fact that trauma has actually produced such a change in any given case must be established by clinical evidence, and is extremely difficult to prove. The natural tendency of such lesions is toward cancer, and clinical observation shows that the vast majority of such injuries to precancerous lesions heal as do normal tissues, while some may actually interfere with the further progress of the lesion.

One occasionally notes, especially in German literature, the policy of assuming that while a trauma has not originated the cancer, it has acted upon a slumbering tumor anlage, and caused it to become an active carcinoma. This policy avails itself of several unwarranted assumptions. (1)—What is the tumor anlage? If it is a precancerous lesion or a tissue rest there can be no evidence that such things existed at the injured point. (2)—If such abnormalities exist, we have no evidence that trauma does cause them to change their course and become cancerous. (3)—If the anlage is a miniature cancer, there can be no proof that it exists or that the trauma accelerates the growth. On the

contrary, the observations of Lubarsch and Marsh show that even with established cancers, trauma is just as likely to interfere with the growth as to accelerate it. In all such cases it is impossible to establish a reasonable probability, by a series of assumptions, and it is far more reasonable to look for the ordinary known causes of the cancer.

Consideration of special tumor types

Neurofibroma is a manifestation of Recklinghausen's disease. This remarkable dyscrasia, in all its phases, may be traced back to an hereditary and congenital disturbance in the fetal ectoderm affecting mainly the skin and nervous system. When one reviews the various disorders attributable to neurofibromatosis, notes the occasional occurrence of tumors and observes how uniformly the tumors are associated with other features of the dyscrasia, the conclusion must be reached that trauma can play a very minor part, if any, and that the course of the malady is determined by intrinsic factors.

Experimental studies covering a vast number of experiments in cutting, suturing and transplanting nerves reveals a very moderate regenerative capacity of nerve tissue, always self-limited.

Clinical experience reviews the innumerable lacerations, fractures, amputations, nerve sutures, infections, to which nerves are exposed and can point only to the low grade amputation neuroma as evidence of neoplastic tendency.

Dupuytren's contraction, or rider's hand, is a neurofibroma, but results from repeated blows and stretching. Desmoid tumors probably include a neural element, but here again continued stretching enters. The literature contains few references to traumatic neurofibroma. In several cases in which the patient has attributed the tumor to injury, I have been unable to substantiate the claim, but occasionally the history is difficult to analyze. The fact that neurosarcomas recur repeatedly after operations (in one case 21) while retaining the original structure unchanged, renders aggravation extremely improbable. Rather frequently injury brings to light an unsuspected neurofibroma.

Lipoma and Liposarcoma

According to Toldt, fat tissue develops from isolated embryonal fat anlage or organs, each with an independent system of blood vessels in the meshes of which the fat tissue forms by infiltration of perivascular cells. The common lipoma illustrates this mode of origin by producing a multi-lobed tumor mass which is so isolated from the surrounding fat tissue as to suggest a separate blood supply. It is difficult to conceive how trauma can provide such a separate set of blood vessels. All that trauma may do is to disarrange the pre-existing blood vessels and allow the growth of separate individual fat cells. These effects are constantly seen in the regeneration of injured fat tissue, with the production of oil cysts and the proliferation of fat cells about them and foreign body giant cells, yielding the picture of traumatic fat necrosis.

The spontaneous appearance, multiplicity, symmetrical distribution, frequent admixture with angioma and neuroma, and striking association with hereditary neurofibromatosis, all compel one to assign the origin of lipoma to congenital or acquired disturbances of structure of the affected tissues, and nutritional abnormalities.

Nevertheless, the literature contains many references to alleged traumatic lipomas in a few of which the sequence of events is suggestive of a traumatic origin. Wolff reports one case following a single trauma, and adds three others referred to multiple injuries about the shoulder. Lieschke's collection of 81 cases includes a miscellaneous clinical material in which there is no evidence of any special effort to scrutinize the facts. With the same facility Bosse and Lieschke referred several cases of scrotal lipoma to contusions. On the other hand Wurz found only one of twenty-eight cases in which a traumatic origin could be considered. Stern considered the general pathology and clinical features of lipoma and rejected the traumatic theory entirely.

That repeated traumas may induce the growth of certain peculiar types of lipoma such as lipoma arborescents of the knee joint, or lipomas about old inguinal and ventral hernias, etc., is suggested by more direct and acceptable evidence. The rupture of joint capsules or intermuscular fasciae may allow the hernial protrusion of fat lobules, which by repeated impacts, venous congestion, and gradual traction, may induce a low grade of neoplastic growth. It is probably through such indirect effects that any lipomas actually attributable to trauma must be explained.

Since fat tissue may react to injury by active proliferation of fat cells the basis is laid for the development of liposarcoma after trauma. Clinical experience indicates that in rare cases, crushing injuries involving fat tissue may result in certain forms of liposarcoma. In these cases the previous integrity of the tissue may be a reasonable assumption, the adequacy of the trauma is attested by its severity, and the continuity of symptoms connects the tumor directly with the tissue damage, so that little ground may remain for rejecting the traumatic theory of origin.

> An intelligent woman stated that she was in the habit of striking her thigh against a projecting bureau while passing through her apartment. After some weeks a persistent lump formed at that point, and after successive blows the lump enlarged to the size of an egg.

In the sixth month it was excised and the tissue showed an active diffuse growth of atypical fat cells with distinctly sarcomatous features.

In the writer's experience it is the adult type of liposarcoma with opaque granular spindle and polyhedral cells which seems to follow trauma. The embryonal type of myxo-liposarcoma or pure myxosarcoma, commonly occurring in the groin, is of embryonal origin, and in the writer's material, has not been preceded by trauma.

Bone tumors

The reactions of bone tissue to injury, fracture, and other severe traumas give evidence favorable to the theory that severe trauma may be the essential cause of certain benign and malignant tumors of bone.

Starting with this broad assumption it becomes necessary to determine what are the reactions to injury which suggest a relation to sarcoma and what are the types of bone sarcoma which may possibly be referred to trauma.

After fracture, especially when imperfectly immobilized, there may be excessive callus formation yielding a tumor-like swelling clinically resembling sarcoma. In a case of fracture of the clavicle a tumor mass 5 cm. formed in 18 days, which was resected as sarcoma. It showed very active growth of practically normal bone arising chiefly from muscle tissue and some islands of atypical cartilaginous callus. In myositis ossificans the reactions are usually those of excessive production of normal bone with much atypical cartilage. Yet in some cases the reaction may show a very cellular tissue resembling sarcoma with atypical bone and very atypical cartilage such as are seen in some osteogenic sarcomas. It is a notorious fact that many limbs have been amputated for sarcoma because the tissue strongly resembled osteogenic sarcoma. In one case the tissue removed four weeks after a football injury was passed as sarcoma by five pathologists in different parts of this country, but the case ran the usual favorable course of myositis ossificans. It is thus apparent that the reaction of bone to injury often approaches the character of osteogenic sarcoma, especially those types which form bone and cartilage. What factors turn the balance into a true malignant sarcoma are not known.

That some entirely new factors, not connected essentially with the injury, do enter into the case when a true sarcoma results, is strongly indicated by the vast number of fractures, operations on bone, bone grafts, etc., which never develop sarcoma. Special injury to blood vessels or muscle may be excluded because the apparent traumatic sarcomas do not usually involve muscle or produce extensive hematomas. One is thus forced to resort to the theory of local predisposition, about which nothing definite can be said.

A more substantial explanation is that there has been a pre-existing silent tumor focus which is brought to light by the injury. Immediate radiographs have often disclosed the presence of such a pre-existing tumor. If the practice of taking radiographs immediately after bone injuries were universal, I believe the majority of alleged traumatic bone sarcomas would be eliminated.

In the general etiology of bone sarcoma there are many facts which tell against the traumatic theory. The disease belongs to young subjects or young adults, indicating that it is due to some disturbance of growth resulting from intrinsic factors. Chondromas are often multiple and hereditary and occasionally osteogenic sarcoma appears in several bones. Bone changes are common in scurvy and rickets and those in rickets are certainly connected with some of the medullary chondro and osteosarcomas. There are many other forms of nutritional disturbance in bone which may well form the basis of tumors. About 8 per cent of cases of Paget's disease in adults develop osteosarcoma (Codman) and nearly all cases of osteosarcoma in elderly adults arise on this basis. Osteitis fibrosa is common in young subjects, and it may well be regarded as a probable basis for sarcoma in early periods of life. In many cases of osteogenic sarcoma the bone marrow shows changes of the same general type as in osteitis fibrosa. There have been some reports of traumatic osteitis fibrosa cystica, but this disease must now be attributed mainly to disturbances in calcium metabolism.

Infection probably plays a definite role in some cases. Primary abnormalities in the blood vessels are probably related to the telangiectatic types of bone tumors. Clinical experience shows that the great majority of osteogenic sarcomas arise without any traumatic implication, and that the vast majority of bone injuries heal normally. Therefore, when sarcoma of bone follows trauma there is a strong presumption that the disease is not caused by the trauma but results from one or more of the above conditions which are positively known to produce it.

What types of malignant bone tumors may be considered as possibly traumatic?

The character of the reaction of bone tissue to injury indicates that only the bone formers and their variants may safely be referred to trauma. Atypical exuberant cartilaginous callus and atypical bone trabecula are prominent in this reaction and these elements belong chiefly to that group designated by the American Registry as medullary and subperiosteal sarcoma. Formerly this group was termed simply "periosteal sarcoma," but it has now been subdivided.

The bone forming tumors are composed of large polyhedral and large spindle cells and occasionally

mononuclear tumor giant cells, and much or little atypical poorly formed cartilage and bone. The recognition of the possible variants of this group is the task of an experienced tumor pathologist.

The true periosteal sarcomas are composed of small spindle cells and seldom or never contain any trace of bone or callus. They presumably arise from the outer layers of the periosteum. In the writer's experience the few cases of osteogenic sarcoma which seemed probably of traumatic origin have been of the bone forming type.

> A boy of 18 years carrying a heavy sack of mail over freshly broken stone fell and suffered a contused and lacerated wound over the middle two-thirds of the tibia with some bleeding. The limb remained painful for two months, swelling was noted in the third month and a radiograph after the fourth month revealed irregular nodular thickenings over the injured area. In the amputated limb the anterior portion of the shaft of the tibia over a segment six inches long was the seat of a cellular sarcoma with much atypical cartilaginous callus and poorly formed bone.
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> A boy of 14 years playing basket ball received a severe blow above the inner femoral condyle. There was severe pain and immediate swelling and discoloration of the skin and he was helped home and put to bed. After two weeks the swelling had partly subsided, but then remained stationary, increasing slowly after the fourth week. In the eighth week a radiograph disclosed a destructive process affecting 2 inches of the shaft and contiguous medulla with a marked painful tumor of the soft parts. Roentgen therapy produced only slight temporary relief and the leg was amputated in the fourth month, but death followed from pulmonary metastases. The tumor was a very vascular and cellular subperiosteal and medullary bone forming sarcoma.

To what extent the acceptable cases of traumatic bone sarcoma in the literature follow this type cannot be determined because the structural types are not usually reported. At present the writer's cases are too few to permit the assertion that all traumatic bone sarcomas must necessarily be of the bone forming type. Sebestyen reported three cases of bone sarcoma following shortly after war injuries, all of which were bone formers. The medullary osteosarcomas, chondrosarcomas and myxomas find their best explanation in congenital or acquired abnormalities in the structure of the bone. The tissue of origin of these tumors is well protected from injury. In endothelioma of bone I am disposed to discount the occasional history of trauma because the structure indicates an origin from structural anomalies in the fine blood vessels of bone and bone marrow. The subjects are usually of delicate constitution and the vast majority of cases give no history of injury. The various types of myeloma must be referred to infectious and nutritional disorders. Liposarcoma is a medullary tumor of obscure etiology.

The recent demonstration that giant cell tumors are essentially a phase of Recklinghausen's disease, osteitis fibrosa cystica, that this disease is often associated with tumors or functional disturbances in the parathyroid glands with excessive mobilization of calcium, that the disease may be cured by extirpation of the parathyroid tumor, and produced in its main features by administration of parathormone, leaves little basis for the traumatic theory of origin of these common lesions. (Barr, Bulger, Lit.) (Jaffe, Bodansky). In some cases the giant cell tumors have appeared in nearly every bone in the body. In many others they have appeared in one bone at one time and later in other bones. Efforts to produce giant cell tumors by inducing traumatic hemorrhage have failed. Teichmann introduced magnesium needles into the marrow in dogs, producing cavities which, after the resorption of the magnesium, were filled with normal marrow tissue. He concluded that trauma alone is insufficient to produce bone cysts. A primary absorption of bone trabecula by calcium withdrawal with a peculiar and specific reactive process not seen after pure trauma seems to be the regular sequence of events in the origin of these tumors. If giant cell tumors result from trauma they should show definite evidence of organizing blood clot or chronic inflammation in fat tissue, but these signs are generally missing in such tumors and when present seem to be secondary changes. In view of these considerations, any history pointing to the traumatic origin of a giant cell tumor must be scrutinized with the greatest care.

Chordoma

Ardoin concludes a report of miscellaneous cases of supposed traumatic tumors by relating four cases of chordoma in which he was able to obtain a history of trauma. In his case No. 2 the trauma as described was adequate, since the patient fell a distance of 2 meters striking on the sacrum with severe pain and urinary disturbance lasting two weeks. Ten months later painful micturition appeared and a tumor gradually developed over the whole posterior surface of the sacrum. In the other cases the nature of the trauma is not clearly stated. It does not appear that the author paid due attention to the natural history, known conditions of origin, and long latent period of chordoma. There were no data on the previous condition of the patient. Stanton reports two similar cases, in one of which the man sat down hard on the coccyx two years before, and in the other the patient remembered a blow on the head four years before.

Cancer of skin

Cancer has often followed wounds of the skin, but with rare exceptions the connection between the trauma and the cancer is indirect. The types of wounds followed by cancer of the skin are nearly always complicated, the long interval of several years permits other factors to enter, so that it is difficult to determine whether the cancer is chiefly referable to the injury or mainly and essentially to the subsequent and complicating events.

Lacerated wounds which become infected and heal slowly may leave large scars which in exposed situations are subjected to unusual irritations and under these circumstances cancer occasionally develops, usually after a long interval. The entrance of foreign bodies, such as fragments of wood, steel, earth, clothing, etc., delays healing and alters its course so that cancer may result. In rare instances this result is observed within a few months, and without complete healing of the wound. The connection is then rather direct.

Injury of underlying bone with chronic osteomyelitis has in some cases been complicated by cancer of the skin, usually after a long interval. Repeated wounds, the one acting upon the scar tissue of the other, appear to be the most common sequence of events in traumatic skin cancer. Wounds and infections of burn scars are well known to lead to cancer, but as a rule only in very old scars. Here the question arises whether the cancer is the result of the burn or is a wholly new process dependent upon the predisposing condition in the scar.

> Carnett and Burton reported a much quoted case of traumatic cancer of the skin occurring in a boy of 22 years who received a lacerated wound of the forearm while playing baseball. The wound never healed but developed extensive suppuration. The process was a very anaplastic carcinoma not squamous and the date of its appearance was not determined. The patient died of pneumonia after a total duration of the carcinoma of 1½ years. Here the injury, the suppuration, and the various surgical procedures must be considered in the origin of the cancer.

Chemical burns, especially those by hot tar not infrequently lead to cancer, and Gunsett reports cases in which the cancer appeared within a few weeks after the burn. Schad reports two cases of gunshot wound of the face in which squamous carcinoma developed in less than six months.

Haagensen reports from the Memorial Hospital many cases illustrating the conditions under which cancer of the skin may follow trauma. In most of these the circumstances were attested with fair but not absolute certainty.

> A fox bite on the back of hand in 1922 was followed by normal healing, but in 1927, there was scabbing and ulceration, and in 1929 basal cell cancer appeared. A horse bite on hand in 1901 left a scaly area which ulcerated in 1922 and then showed epithelioma. A dog bite in 1919 was cauterized but never healed, remaining crusted, and in 1923 squamous carcinoma appeared. In three cases splinters of steel or wood entered the wound and cancer was found after 7 weeks and one year. A severe blow by a hammer with crushing wound was found to show cancer after one year. A horse tramped on a man's great toe in 1914 leaving a chronic suppurating sore which in 1919 showed cancer.

The familiar traumatic epidermoid cyst results from the transfer of a fragment of epidermis into the derma or deeper tissues. It is generally benign but many become malignant. A similar origin accounts for most, if not all, the tibial adamantinomas which appear within a few months (Fisher) or several years after an injury to the shin (Ryrie) (Holden, Gray, Lit.).

While there is no satisfactory evidence that normal scars are specially prone to cancer, it is clear that such scars are more prone to subsequent injuries and to infection. A very long interval permits the entrance of many new accidents and the appearance of late arsenic or sunlight cancer which might be effective on normal skin. The wounded area may not be regarded as immune to subsequent cancer producing agents. Therefore, the possibility that the late cancer is merely a coincidence must be considered. Since infection and delayed healing belong to complicated wounds, if healing is never complete and bridging symptoms persist and the cancer appears within a few weeks or months, the connection is more direct.

Reviewing the above data it appears that cancer of the skin may be regarded as traumatic only when it develops before healing is complete. When the wound heals normally and remains healed for a substantial period any subsequent development of cancer must be attributed to subsequent events. Otherwise a man who once sustains a wound of the skin would enjoy insurance against all later cancer producing hazards affecting that area, and for the rest of his life. Some form of partial liability would seem to be required for such cases.

Melanoma

The dramatic incident of immediate local recurrence and metastases of apparently benign moles after surgical excision or destruction by nonsurgical methods forms the basis of the wide impression that a single trauma may transform a benign mole into a malignant melanoma. A careful scrutiny of the evidence in such cases does not support this view, but indicates that in all such cases the mole is already

malignant. The good results obtained by dermatologists with thousands of moles shows that when the mole is benign excision or local destruction is a safe procedure. Experience at the Memorial Hospital shows that when a patient requests the removal of a mole it is nearly always because the mole shows signs of growth and when removed it is, with very rare exceptions, already malignant, and requires careful and wide excision. The clinical history of nearly all malignant melanomas indicates that the causes of malignancy reside in the original structure and tendencies of the mole and are not connected with trauma, except in very rare cases. This principle holds particularly with melanomas of mucous membranes and internal organs. For the same reasons when a long standing mole on an exposed position becomes malignant the presumption should be that the change results from inherent tendencies and not from the effects of a single trauma. The majority of such moles never become malignant. Evidence is beginning to appear that the growth tendencies of moles are controlled by the sympathetic system and by means of internal secretions.

In the case of complicated wounds and repeated trauma the conditions are radically different and it would appear that melanoma may result from both these types of injuries and either from pre-existing moles or even in normal tissues, in subjects with local or general predisposition. The rarity of such cases indicates that the predisposition is uncommon.

Schopper collected from the literature and his own experience 25 cases in which subungual melanoma followed severe injuries with infection, or avulsion of the nail, and a variable period of chronic inflammation. He thought a naevus need not precede the melanoma.

Reviewing these cases I find it difficult to determine just what part was played by the injury. In one case the patient split the entire length of the thumb nail by an apparently mild blunt injury. The split remained unhealed for five months when slowly progressive growth of tissue appeared, with ulceration and later melanoma. This patient's hands were daily exposed to quicklime and the unusual result of the slight initial injury suggests some previous pathological condition in the nail bed. In another case the patient ran a splinter under the nail, the wound never healed, and 1½ years later melanoma was recognized. This brief report relates only to those facts favoring a traumatic origin. Schopper refers to many spontaneous subungual moles and melanomas with much the same history as the traumatic cases, reported by Heller and by Rockock. He concludes that trauma alone is incapable of producing subungual melanoma, but that infection must be added. In a series of cases of subungual melanoma, Adair and Pack were not impressed with the importance of trauma, and nearly all their cases presented themselves because of definite signs of an active process without trauma.

I have an impression that many of the very malignant carcinomas of the skin following repeated trauma or complicated wounds are melanomas. A young baseball catcher repeatedly injured the thumb, developed a fissure which did not heal after two unsuccessful efforts at surgical removal over a period of six months and was found to have a cellular melanoma with metastases in cubital node.

A young girl suffered from excoriation of the skin of heel from a misfitting shoe. A horny wart developed after a few months which progressed rapidly, recurred promptly and produced general metastases. The structure was that of highly cellular slightly pigmented melanoma. An adult male allowed a projecting nail in his shoe to irritate the sole of his foot for several months. Soon there was pronounced pigmentation of the skin about the fine central punctured point extending superficially over a centimeter. The biopsy showed melanoma. The patient denied the previous existence of any mole and stated that the pigmentation appeared only after several weeks. It is said that the barefooted Sudanese natives frequently suffer from melanoma of the sole of foot after thorn pricks. (Dawson.)

Ocular melanoma

The state of opinion regarding the traumatic origin of ocular melanoma is well reflected in the report of a case by Stieren and its subsequent discussion. In this case the patient received a lacerated wound of the conjunctiva and adjacent tissue which healed normally in two weeks. Nine years later he appeared with a small melanoma on the side distal to the injury, with detachment of the retina. In spite of the absence of any signs of definite injury to the eyeball, the unsatisfactory location of the tumor on the opposite side, the very long interval, the history of ocular disturbance for only six months, and the absence of any attempt to trace the possible mode of action of the trauma, it is stated that Segond's postulates are fully met and the case must be accepted as traumatic. This conclusion was vigorously rejected by Verhoeff who analyzed the case, pointed out the various deficiencies in the evidence, and reported that in the examination of over 300 cases of ocular melanoma he has never seen any evidence of trauma. Bancroft then followed with the usual clinical statistical report that of 126 cases of ocular melanoma 9 gave a history of trauma, but admits that the relation of trauma may have been merely incidental.

All the objections to the traumatic theory of cutaneous melanoma apply with added force to intraocular tumors.

Ophthalmic literature would be much enriched by a single report of a case in which the known conditions of origin of melanoma are fully considered, the effects of an authentic and adequate trauma clearly stated, the probable relation of the trauma to the melanoma carefully traced, the time interval satisfactory, the gross anatomy and structure of the tumor shown to be consistent, and all the facts required for an adequate medico-legal opinion provided, and pointing beyond reasonable doubt to the traumatic origin of an ocular melanoma.

Glioma of the brain and cord

The traumatic origin of glioma of the brain and cord has been extensively discussed for many years and opinions regarding its frequency and the mode of action of the injury have varied widely. Adler collected 1086 cases of glioma of the brain, of which 8.8 percent were preceded by a rather definite history of trauma. The critical study of Parker and Kernohan showed that of 491 cases of glioma of the brain 4.8 per cent could be considered as possibly of traumatic origin, although 13.4 per cent gave a history of previous skull injury. Yet in an equal number of other patients 10.4 per cent gave a history of severe skull injury and of 200 normal persons 35.5 per cent gave a history of skull injury. They also followed 2858 war injuries of the skull for 14 years without finding a single brain tumor. Vogeler, Ackerman and others report 2775 cases of skull injuries followed for many years, finding a great variety of neurological sequels but no tumors. Since there are very few persons who have not at some time suffered a substantial injury to the skull, the history of such an injury at a distant date creates no assumption in favor of the traumatic origin of a tumor.

> Beneke has argued strongly in favor of the frequent occurrence of traumatic brain tumors, relying especially on the doctrine of spastic contraction of the vessels as a cause of necrosis of tissue and later of gliomas. In his experience 40 per cent of all gliomas give a history of severe or slight injury to the skull, raising a presumption that the tumor is the result of the trauma. Even slight injuries or even psychic trauma such as fright or sudden emotion must be accepted as causes of brain tumors. The pathogenesis of these traumatic tumors he conceives as follows:—At the point of the injury or at any distant point in the brain trauma may cause an arterial spasm. This spasm results in ischemic necrosis of brain tissue. On the edges of the necrotic area arises active proliferation of glia tissue becoming malignant through the action of the products of degeneration, necrose hormones of Caspari, mostly lipoid. By careful histological examination he claims to have been able to accurately identify the primary area of necrosis and the tumor process arising about it, and thus the scientific demonstration of the traumatic origin of the tumor has been furnished. In many instances he believes he has been able to determine the rate of growth and the duration of the tumor, and thus to establish the proper time relations between injury and tumor. The theory that gliomas arise from tissue rests or other congenital anomalies of structure he rejects as without foundation, since no one has ever seen such rests or anomalies.
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> This sensational doctrine did not long escape challenge. Within a few months Fischer-Wasels submitted Beneke's argument to a merciless analysis. He first asserts the wide scope of the embryonal origin of brain tumors, referring to Kornfeld's recent report on the frequency of tissue rests in the brain and meninges. He sharply denies the possibility of determining the age of necrotic foci or the age of tumors from histological data. He points out that skull injuries are so frequent that 99 per cent of all brain tumors would be attributed to trauma if Beneke's criteria were followed, and yet such tumors are exceedingly rare and did not increase in frequency after the war. Referring to Ricker's doctrine of arterial spasm following trauma he finds that severe trauma with unconsciousness may induce irritability and spasm, but as Ricker stated, never necrosis. In migraine and epilepsy there is severe arterial spasm but no necrosis. The idea that mild injury or psychic shock can produce necrosis he rejects as wholly lacking foundation. He points out that tumors never develop about anemic infarcts or other necrotic foci but only about old scars and after a long period of regeneration. Finally he cites a case in which a large glioma developed about scar tissue nine years after a gunshot wound of the brain, and he accepts the traumatic origin of such tumors arising under such circumstances, and as long as from one to twenty years after the injury, but not within one year.

One of the most significant features of this debate is the fact that in one of Beneke's cases, an experienced observer accepted without question the statements of the claimant which strongly favored a traumatic origin of the tumor, but that when the actual clinical facts were secured, a history of severe cerebral attacks before the accident was established and the traumatic origin was clearly excluded.

Accordingly, for brain tumors, one may not relax in any way the rigid criteria required to establish a traumatic origin. When it can be shown that the tissues of origin have been lacerated, and the tumor arises in the injured area, and

after an interval sufficient to permit of regenerative processes, and the tumor is of ordinary gliomatous type or other suitable structure, then a traumatic origin may be entertained. Rare cases meeting* these requirements have undoubtedly occurred and have been reported. It is especially in the scars of injuries that such tumors arise (Beneke, Fischer-Wasels, Reinhardt, Neuberger).

Cancer of breast

It has long been known that mammary cancer never arises in a normal breast but always on the basis of previous anatomical alterations. These structural alterations take a great variety of forms, as chronic cystic mastitis, fibrous atrophic mastitis, simple fat atrophy, scars of old abscesses, displaced islands of gland tissue, atypical recurrent fibroadenomas, eczema of nipple, catarrhal inflammation of nipple and terminal ducts, tight nipple, papillomas of the ducts.

All these abnormalities adequately account for the occurrence of the vast majority of cases of mammary cancer, anatomically considered. However, since cancer often fails to develop on these lesions it has been necessary to determine some other exciting factors. One of these factors has long been recognized in the presence of stagnation of secretion in the cancerous focus and generally throughout the breast. The stagnation theory has received substantial support in recent years, from pathologists and clinicians. It has been shown, especially by Adair, that mammary cancer is much more frequent in childless women. In practically all cases of the ordinary forms of breast cancer I find stagnation of secretion in such relation to the cancer as to strongly suggest that the cancer arises as the result of local irritation of the altered secretions. Cheatle has shown in large sections of the breast the mode of origin of the lesion which obstructs the ducts.

In recent years experimental studies have thrown much light on the mode of origin of mammary cancer. Bagg produced mammary cancer in a high proportion of mice by removing the young at birth or by ligating the ducts on one side and allowing the young to suckle on the other side. Cancer developed in the non-nursing breasts, and on the ligated side only, and as a rule rather promptly. Bagg attributed the results to functional hyperactivity and stagnation. The factors of functional hyperactivity and stagnation have received impressive evidence from the work of Murray, Lacassagne, Little and others who have produced mammary cancer by implanting male mice with portions of ovarian tissue. In many cases the male breasts became hypertrophied, distended with secretion, and cancer resulted.

There is thus an extensive body of evidence showing that cancer of the breast develops under rather peculiar and specific conditions, readily demonstrable, and that in the absence of these conditions the disease does not appear. Therefore, in all alleged traumatic breast cancers search should be made for some of the above, conditions and when they are found the conclusion that the disease depends upon these conditions and no others rests on a substantial basis. Moreover, the various efforts to produce cancer in lower animals by traumatizing the breast, as done by Lubarsch, Ribbert and others have uniformly failed. Marsh attempted to affect the incidence of spontaneous tumors of the breast in breeding female mice by mechanical injury of the breast tissue. Two series of 18 young breeders in each were used. One was injured on the right side only, the other on the left side only. The injury was continued regularly every three days, save for intermissions for recovery from the lesions, throughout the lives of the animals. Breeding was interfered with and the life period shortened to an average of nine months. The development of only three tumors where many were normally expected marks the experiment a failure (Personal communication).

Nevertheless, medico-legal practice meets a difficult problem in determining the influence of trauma in alleged cases of traumatic mammary cancer. When a woman states that she received a severe blow on the breast, followed by pain, swelling and discoloration with persistent symptoms for a period of weeks or months, with or without a symptomless interval, and when cancer later appears at the point of injury, the possible importance of the injury may be dismissed only after the careful application of all the criteria demanded to establish or exclude a traumatic origin. The inquiry, therefore, involves a laborious program of fact-finding.

The authenticity of the trauma may not rest on the mere statements of the patient, but should be corroborated by eyewitnesses and by signs of injury attested preferably by a physician. The trauma must be adequate to produce some structural alteration in the breast tissue and attended at least by hemorrhage. The innumerable mild blows which every woman's breasts sustain can hardly affect the breast tissue protected by a layer of fat one half to one inch thick.

The tumor must arise at the exact point of the injury since transmitted effects may be excluded in the average breast. The probability of coincidence is very great, and when a mild blow produces unusual pain the previous existence of a tumor should be suspected. Most cases of alleged traumatic breast cancer may be dismissed beyond a reasonable doubt when the cancer arises in a segment of breast which is the seat of old chronic fibrous or cystic mastitis or other predisposing anatomical lesions. There is no definite evidence to show that trauma to such lesions may precipitate a cancerous process. It is just as likely to be followed by cicatrization.

The only type of mammary cancer that can reasonably be referred to trauma is carcinoma simplex which might conceivably grow from ruptured ducts into scar tissue. Diffuse duct carcinoma, adenocarcinoma arising in cysts,

embryonal cancers, carcinomatous fibroadenomas, inflammatory carcinomatosis, and Paget's disease, are not reasonably explained by trauma.

The time factor excludes many alleged cases. Scirrhus cancer does not appear within a few weeks. In the less malignant adenocarcinomas the lymph nodes are not usually involved within a year. Except in the more malignant types skin adherence does not occur for some months. There is always a period of some weeks or months when mammary cancer fails to give symptoms.

Therefore, in each case the entire clinical history must be secured and the tumor and the entire breast must be examined by a competent tumor pathologist before the basis can be laid for an opinion. When all these data are carefully gathered and analyzed, it has been the writer's experience that cases of mammary cancer in which a traumatic origin can be reasonably accepted are extremely rare.

At the present time the attitude of the general surgeon toward the traumatic origin of mammary cancer is very uncritical, and the task of fact finding is replaced by unwarranted assumption and speculation. That even experienced observers may fall victims of self deception is illustrated by the following case, originally reported by Rasch and cautiously interpreted by him as traumatic cancer, but later circulated as such in German periodicals.

> A woman of 64 years, in March, 1929, suffered a punctured wound in the midsternal line by a wire which was wrapped around a small bunch of flowers. Three days later a physician found a reddish area about the wound 5 cm. wide. In the following weeks (exact dates not given), a reddish discoloration appeared in the skin of breast. (Exact location and extent?) Treatment by x-rays for three days was without effect. By September the patient had lost appetite and was much reduced in strength and the process had extended to the other breast and down to the navel. No definite tumor could be found either in the breast or in the skin. The axillary nodes became enlarged (date not given). Death occurred in June, 1930. Sections of the skin showed the characteristic highly malignant structure of diffuse duct carcinoma, which infiltrates the dermal lymphatics. The entire picture is typical of diffuse inflammatory duct carcinoma in which there is no localized tumor of the breast, but rapid dissemination through the skin with erysipeloid reaction. The wire puncture may possibly have added a local inflammatory element to a preexisting diffuse carcinoma, but it could not possibly have originated the growth of the carcinoma because there is no breast tissue in the mid-line of the sternum. For the reader the deception is completed by placing over the puncture point a circle of white dressing fastened by four radiating lines of white rubber plaster, which rivets the eye and precludes further scrutiny of the case.

Carcinoma of the lung

Clinical medicine assigns as etiological factors in carcinoma of the lung, tuberculosis, influenza, productive and interstitial pneumonias, exposure to irritating gases, including possibly petroleum products. The Schneeberg's miner's cancer may be due to radium rays. These diseases satisfactorily account for the observed cases and very few modern authors mention trauma. Adler found 6 among 384 cases with a record of previous trauma but the reports are not impressive and are of the usual clinical type. I would also reject the cases of Aufrecht and Curran. Lepine in 1903 gave a short but rather specific account of a case which may well have been of traumatic origin and which illustrates the conditions under which such an origin may be considered.

> A man of 60 years, previous history not given, was struck on the 7-8″ ribs in the posterior axillary line by a moving wagon, producing a prompt contusion. There was no hemoptysis and interval symptoms were lacking. One year later he appeared with signs of lung cancer which was soon fatal with gangrene. The autopsy disclosed a squamous cancer of the lung, mandarin size, opposite the point of injury and with pleura adherent to this point. There was a perforation of the chest between the 7-8″ ribs and the pleura was concentrically thickened about the sinus.

I have investigated several alleged cases of traumatic lung cancer, but failed to find any definite indication of such a relation. Most of these tumors, as usual, were located at the root of the lung and in none was the tumor primary at the area of alleged trauma.

Gastric cancer

The anatomical features of beginning gastric cancer and its general etiology are rather well known and they are incompatible with a traumatic origin.

Verse described twelve small unsuspected gastric cancers discovered at autopsy. They were single, occasionally multiple, slightly raised, circumscribed adenocarcinomas, generally infected, eroded or slightly ulcerated and .5 to 2 cm. in diameter. I have seen three such lesions. They represent about all that we positively know about the origin of the ordinary form of this disease. In another rarer group the lesion first consists of a rather diffuse focal hypertrophy of lining cells with multiple superficial adenocarcinomatous areas tending to ulceration. This same diffuse process

extending over a rather wide area may affect the chief cells of the glands giving rise to the superficial small cell variety of cancer. A few cases of gastric cancer arise from isolated islands of gastric mucosa lying in the mucosa or submucosa. Cardiac cancer probably results from a similar heterotopia of gastric or esophageal mucosa at the cardiac orifice.

Cramer summarizes the present statistical knowledge of the occurrence of gastric cancer with the conclusion that the disease is dependent on extrinsic factors connected with the dietary habits of the people. We have thus a very comprehensive body of evidence which fully accounts for the occurrence of gastric cancer apart from trauma.

It is, therefore, not surprising that the efforts of occasional authors to establish the traumatic origin of certain gastric cancers have not succeeded and have not received serious attention. Probably the most ambitious of these efforts was that of Menne in 1905. I have studied this contribution carefully on two occasions and failed to find in it any tangible evidence of a traumatic origin of his cases, or indeed, any competent effort to secure the facts in the cases. He endeavors to show that single trauma may directly originate gastric cancer, or may accelerate the growth of a pre-existing cancer, or "depleting the system" may hasten the course of the disease, to prove which he relies largely on speculation and assumption. In two of his most striking cases the traumatic origin was vigorously contested by competent pathologists.

Since it is well known that a severe non-penetrating wound may cause laceration of the gastric mucosa, it is necessary to consider under what conditions it may be assumed that such an injury has actually been sustained. Here the authenticity and adequacy of the injury must be properly attested. Persistent pain must result, and vomiting of blood is very common. That such contused or lacerated wounds of the stomach have ever produced cancer has never been proven and is highly improbable.

An important observation by Luckow shows that trauma does not render the stomach immune to the ordinary form of cancer (Cit. by Knox).

> In a man wounded by shrapnel in 1917, examined because of gastric pain in 1928, the x-ray showed splinters of metal in liver, gall bladder and greater curvature of stomach. Laparotomy disclosed an extensive gastric cancer, which had developed, not around the metal fragments in the greater curvature, but in the pylorus where such cancers usually arise.

Gastric ulcer

Stern in a standard treatise on trauma enters fully into the relations of trauma to wounds, ulcers, and cancer of stomach and duodenum. From the extensive data presented it appears that severe blows to the epigastrium may cause lacerations of the mucosa and tears of the muscular coat, that such wounds, with rare exceptions heal promptly and without sequel, that they are nearly always accompanied by vomiting and usually hematemesis, that ulcers may form in a few days and heal either rapidly or slowly, that chronic ulcers may occasionally develop, in which case the form of the ulcer differs from the true peptic ulcer, showing adhesions, suggesting a primary rupture of the muscularis, that no case of typical chronic indurated peptic ulcer has been demonstrated after trauma, and that no case of traumatic ulcer has been demonstrated to run the course of ulcerocancer. In this whole discussion one finds much the same uncertainty regarding the facts as in the usual discussion of traumatic cancer.

The subject of gastric cancer he approaches cautiously and from a judicial standpoint, first pointing out that neither experts nor tribunals should or do adopt the theory, *In dubio semper pro laeso* (in doubt, always favor the injured). Yet when there exists a striking relation in time and location, between an injury and subsequent disease, the expert must not reject the probability of such a relation, unless supported by attested pathological anatomical facts, experimental data, and extensive clinical experience. Yet after announcing this very sound doctrine, he proceeds to review the reports of two cases of gastric cancer and one of the sigmoid which he would accept as traumatic. In so doing, in the writer's opinion, he violates the principles previously adopted.

> In the first case there were no symptoms of injury to the stomach, and the only evidence favoring trauma was the patient's statement that he was well before the injury and sick thereafter. A bulky tumor was discovered in six months and autopsy after 11 months disclosed an extensive carcinoma of the stomach without unusual features. In the second case symptoms of stomach injury were absent, and no injury was discovered at laparotomy. Yet the expert adopted the theory that while the injury did not originate the tumor it probably accelerated the growth of an existing minimal tumor anlage. The patient with sigmoid cancer received a kick in the abdomen, followed by vomiting and abdominal tenderness, especially in the left pelvic region which slowly disappeared. After three years the pain returned and after four years, operation disclosed a large sigmoid carcinoma without unusual features.

Tumors of the testis

With rare exceptions malignant tumors of the testis arise at the rete testis and grow into and distend the body of the

organ. They develop from sex cells, probably misplaced and more or less embryonal, which pursue an abortive course of fetal evolution, producing adult and embryonal organs, in the tissues of which a malignant process is commonly engrafted. The inception of the process is probably similar to that which excites the growth of the normal ovum, but without fertilization. There is no evidence that trauma can initiate such a peculiar process.

There is a rare adenocarcinoma of adult type, described by Bell, which arises in the body of the testis in adult subjects and grows slowly.

The adult teratomas grow slowly, requiring some months to reach a size which demands attention and continuing for two or three years unless interrupted by complications. The malignant carcinomas grow steadily and sometimes rapidly, generally with pain, and often with spontaneous hemorrhage which need not be attributed to injury. A silent period of weeks or months precedes the detection of the tumor and is often masked by hydrocele. The shortest course of a malignant carcinoma of testis which I have been able to find was 18 weeks from the detection of a definite tumor mass until death from metastases.

The normal testicle escapes injury with remarkable facility from all except rapidly moving hard objects. When injured it always gives a peculiar testicular pain which readily runs into shock and the patient does not recover immediately. When the organ harbors a tumor it is easily injured and pain results from minor blows and simple pressure effects. Accordingly, many patients date the beginning of the disease from and assign the origin to trauma.

I have investigated many cases of alleged traumatic tumors of the testis without finding any acceptable. Most of the cases were rejected because the injury was simple muscular exertion with back strain, and the pain was referred to the back or groin. In others, the blow was directed to groin, or thigh, or pubes and not to testis, and testicular pain was absent. In several the size of the tumor and its structure showed that it must have antedated the injury, and in a few metastases were already present.

The literature contains many reports of supposed traumatic tumors of the testis, but most of them are without definite value. It is both affirmed and denied that the undescended testis is more subject to malignant growth, and the difference does not favor a traumatic origin of such tumors. Wasterlain gives a comprehensive review of the opinions of current authorities, all of whom are disposed to reject the traumatic origin except in very rare cases, in which the injury was fully attested and very severe.

> He cites a case reported by Lippens:—A man of 50 years fell on a rail and received a severe contusion of the scrotum with ecchymosis extending to the groin, violent testicular pain with syncope, exquisite tenderness lasting several days and swelling of the testis. The swelling subsided for two weeks, remained stationary for four weeks when hydrocele appeared twice.
>
> For twelve weeks the testis remained swollen and then enlarged nodes in the groin were found, followed by dissemination in seven months. The microscopic diagnosis was malignant tumor of the testis.

The experimental studies of Michalowsky are of much interest. He subjected both the testicles of the cock to many forms of severe trauma but in 100 birds never produced a tumor. However, when he injected chloride of zinc into the testes he secured 10 tumors in 50 birds, but only during the Spring. Bagg has verified these results. These experiments show that the testis of the cock is very insusceptible to malignant tumors following trauma, but very susceptible when the right irritant is employed. They tell strongly against the traumatic theory of origin of these tumors.

Hypernephroma

Stern refers to two cases of hypernephroma as of traumatic origin.

> The first case must be positively rejected because a large inoperable carcinoma of the kidney was found three months after a blow on the flank. Renal tumors do not grow so fast. The second case is of much interest and calls for critical examination. A man of 33 years, on the night of January 6, 1920, stumbled over some boards and struck the left side below the costal border against an iron object. There was severe transient pain. Next morning there were meteorism and colicy pains, and large masses of blood clot were passed in urine. After some weeks a similar attack. February 4, a radiograph showed the kidney of normal size and no stones. Thereafter occasional hematuria after lifting. May 22, 1922, severe back pains. A smooth oval tumor of the kidney, 980 gm. was then removed, the patient recovering. The tumor was partly adenoma, partly solid, with necrotic areas. (Whether renal or adrenal, not stated.) The possibility that this tumor was caused essentially by the injury must be admitted, but the probability rejected.

A traumatic origin involves resort to the hazardous and unproven theory that trauma may excite the growth of a silent tissue rest or miniature adenoma, from which these tumors are known to arise. The previous good health is of no moment. The details of the accident appear not to have been

corroborated. The severe bleeding after an injury of no great severity suggests not a normal kidney but one already the seat of a small tumor. The radiographer, looking for injury and stones might readily overlook a tumor. The period of two years represents a relatively short duration of such a large benign tumor. Such a series of uncertainties and assumptions is hardly sufficient to establish the traumatic origin of any form of hypernephroma.

The lengthy discussions of this subject by Seeliger, Goldstein, and Thiem, written twenty years ago are notable for the profundity of the argument and the superficiality of the fact-finding. They illustrate the futility of attempting to create out of vague possibilities varying degrees of probability.

Ten years later Ruckart reviewed 117 cases of hypernephroma in the literature, found nine in which a traumatic origin was suggested, but concluded that in all these the injury merely called attention to a pre-existing tumor. None of these contributions throw any light on the important question—what causes adrenal rests, and miniature adenomas of the kidney to start growing.

Today there is considerable evidence that the real factor consists in functional demands directed to the miniature organs from which the tumors arise and carried by hormones, especially those of the pituitary gland, thyroid, pancreas, and sex glands.

Cortical hyperplasia of the adrenal occurs under many conditions. It appears whenever there is an excess of Prolan A, and this condition is observed frequently with the decline of the sex functions or after castration. It is often found in acromegaly. Injections of prolan regularly induce marked cortical adrenal hyperplasia. The close relation between the structure and functions of adrenals and testes has been elaborated by Leupold and others. In a case of pseudohermaphroditism with rudimentary ovaries, Marchand found marked hyperplasia of the adrenals and an accessory adrenal as large as a testis. A marked enlargement of the adrenals is sometimes observed in pregnancy (H. Sternberg). Certain cortical tumors of the adrenal possess marked masculinizing powers in both sexes (Glynn, Lit.). The interrelations between adrenals, thyroid, and pancreas were long ago pointed out by Falta, Rudinger and Eppinger. Schur and Wiesel noted cortical adrenal hyperplasia after partial nephrectomy and it is often observed in contracted kidneys. Marked disturbances of renal function are observed with many abnormalities of the hypophysis and with certain tumors of the adrenal gland. These and many other recent contributions reveal very numerous conditions in which unusual functional demands are positively known to produce adrenal and renal overactivity and hyperplasia, and they leave little justification for introducing the element of trauma into the origin of adrenal and renal tumors.

Summary

1. Present data confirm the view, long since adopted by pathologists, that a single trauma of normal tissues is incapable of producing a malignant tumor. This principle may not greatly alter the possible importance of trauma as an indirect but essential and determining cause of certain tumors.
2. Delayed healing due to infection, suppuration, and chronic irritation by chemicals, and foreign bodies, is nearly always observed in cases where a tumor may be referred indirectly to trauma. Even in such cases it seems necessary to recognize the probable influence of heredity, and local tissue predisposition. Repeated traumas, acting on successively altered tissues are more likely to induce disordered regeneration than is a single injury.
3. Only those tumors may safely be referred to trauma, in which the structure represents an exaggeration or variation of the normal healing process and its sequels.
4. The rapid increase in the number of known cancerigenic agents, and the advances in the knowledge of the conditions under which tumors ordinarily develop, adequately accounts for the great majority of tumors, and greatly restricts the probable scope of trauma. When such agents or conditions are detected a presumption is established that the tumor is caused by them and not by any trauma.
5. The chief task in determining the relation of trauma to any given tumor is one of laborious fact-finding. The great majority of reports of alleged traumatic tumors would disappear from the literature if the facts were competently gathered and evaluated. The laws of psychology demand that the statements of patients and eye-witnesses should be corroborated, the actual and probable immediate effects of the injury attested by competent persons, preferably physicians, and the entire case be studied from a broad clinical and pathological viewpoint. In the conduct of this study the various criteria now recognized in medico-legal inquiry must be employed.
6. The probability of coincidence is much greater than is generally recognized. The innumerable and constantly occurring mild and severe wounds and bruises assure that a large proportion of tumors must receive some injury shortly before appearance or during their course.
7. The presence of an unsuspected tumor tends to bring out the occurrence of injuries to the tumor bearing area, and to intensify the subjective symptoms and local effects of injury. This principle may be designated as traumatic determinism.
8. Aggravation may be accepted when injury introduces into the course of a tumor significant features

deleterious to the patient, and which do not normally occur in the course of the disease, at approximately the same time. It should be recognized that injury often causes temporary complications, the effects of which pass in due time, without altering the general course of the disease. The idea that injury usually accelerates tumor cell growth is not supported by clinical and experimental data, and applies only to severe injuries in advanced stages of disease.

9. It is reasonably well attested that trauma may cause the localization of metastases, and the appearance of metastases which might not otherwise occur, but only in the advanced stages of malignant tumors when tumor cells may frequently escape into the blood, at which time the metastases do not alter the course of the disease.
10. Opinions regarding the possible traumatic origin of any tumor must be based on full consideration of the location, known conditions of origin, structural peculiarities, and clinical course of the tumors in each organ. Generalizations may be invalid or misleading. Such inquiries belong to the broadly trained clinician and the experienced tumor pathologist.
11. The interpretation of compensation laws should recognize that trauma is never the sole cause of cancer, and often only a subordinate, although determining cause, that the probability of coincidence is very great, that aggravation by injury is rare and difficult to establish, and that many difficulties and uncertainties will continue to surround this subject for a long time to come. Some form of partial liability seems necessary to meet these conditions. Without it the compensation law becomes a form of sickness insurance against the natural occurrence and ordinary consequences of one of the major causes of disability and 10 per cent of the deaths.
12. There is urgent need of more competent detailed analysis of individual cases of possible traumatic tumors, more extensive studies of the effects of trauma on different organs and tissues, and more accurate statistical studies of the incidence, course, and complications of all forms of benign and malignant tumors.

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