Review Article

Inflammation: John Hunter’s A Treatise on the Blood, Inflammation and Gun-shot Wounds

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Summary. John Hunter’s A Treatise on the Blood, Inflammation and Gun-shot Wounds was published in 1794. Throughout the nineteenth century this was considered the most important study of inflammation and has been widely quoted since. After a section on the nature of blood and the circulatory system, in which he describes the vascular supply in detail, he passes on to an extensive survey of inflammation. This is based mainly on his wide clinical experience, including that as a military surgeon. He, however, supplements this with a number of experiments, some of which are classic. He bases his observations on the four cardinal signs of Celsius (redness, heat, swelling and pain). Inflammation is then divided into three main groups: adhesive, suppurative and ulcerative. He discusses the nature of pus and the formation and treatment of abscesses. He describes his experiments on the transplantation of tissues under the general heading of adhesive inflammation. This, he states, underlies the union of wounds and thus the union of tissues after transplantation. Although unaware of the role of infecting organisms as a cause of inflammation, he makes observations on inflammation in smallpox, venereal infections and tuberculosis. He relates these to his observations on inflammatory aspects of wound healing. Lister was particularly influenced by Hunter’s observations in the development of antisepsis. As well as the local effect of inflammation, Hunter was concerned with the constitutional effects such as fever.

Keywords: John Hunter, inflammation, vascular, adhesive, suppurative, ulcerative

John Hunter’s (Figure 1) interest in inflammation went back to 1760 when he served first as a surgeon on the staff of the military expedition to Belle Ile (off the northern coast of France) and subsequently in Portugal during the Seven Years War (1756–1763). During this time he had considerable experience on the effect of gunshot wounds. In the subsequent years, before his death in 1793, he put down his thoughts and experience on the subject in his famous A Treatise on the Blood, Inflammation, and Gun-shot Wounds, which was published posthumously in 1794. This had a considerable influence on pathological thought throughout the nineteenth century. A new survey of his observations might be relevant 200 years later.

Hunter had a special interest in venereal infection and in smallpox inoculation. He was aware that syphilis and variola could be transmitted by injection and had some knowledge of the infectious nature of certain diseases. In the introduction he describes how an attack of measles can inhibit a delayed type hypersensitivity...
reaction. In this case the reaction was an early response to the injection of variola which had developed on the third day. This is comparable to the well known inhibition of the tuberculin reaction by measles, an observation made over a hundred years later by von Pirquet (1907).

Blood and circulatory system

The first part of the book describes the blood and the circulatory system, particularly in respect of their role in inflammation. Blood may be observed with the microscope as containing globules (red cells) circulating in the vessels. The other part is coagulable lymph or serum. Blood coagulates when out of the body, but it may also coagulate within the body in certain disease states. Blood coagulates more quickly in vitro than when extravasated into the tissues. He then describes experiments on the effect of heat and cold on freshly drawn blood. He notes that if there is mortification (gangrene) of the foot, he can find the crural and iliac arteries filled with highly coagulated blood.

After talking about coagulation he goes on to discuss the components of coagulated blood serum and red cells (globules). When blood separates before coagulation, another layer appears between the two. This is the buff (or Buffy layer). The proportion of serum coagulated by heat could be estimated, as also could that coagulated by water. Similar effects could be obtained with ascitic and amniotic fluids. In the section on red cells he notes that arterial blood is scarlet and venous blood darker. The scarlet colour is related to contact...
with air and this takes place in the lungs. He devised a series of experiments using artificial insufflation of the lungs to demonstrate the effect of air in inducing a scarlet colour in blood issuing from the pulmonary vein. Arterial blood becomes dark in various clinical situations, especially in cardiac disorders where there is a lack of the due influence of air on the blood. In one of these cases, a long-standing aortic stenosis resulted in a restriction of blood flow to the lungs, as a result of which the individual became cyanosed when undertaking excessive exertion. He also quotes a similar case with an intraventricular septal defect and illustrates further the difference in colour of arterial and venous blood by experimental and other clinical observations.

The next section in the chapter on the general principles of the blood concerns the effect of freezing on living matter. He starts with experiments on hen’s eggs, using the development of putrefaction as a marker of cessation of life. He then transferred his observations to live animals to see whether life could return to a part of the body after it had been frozen. He performed experiments on freezing the rabbit’s ear. After being frozen for an hour the ear was thawed, and became warmer and thicker than usual due to ‘inflammation’. Similar experiments were performed on a cock’s wattle, where the inflammatory process took a month to recover. Other experiments were on the effect of temperature on muscle. With this series of similar experiments, Hunter concluded that blood was alive and not inanimate. However, death can occur without the muscles contracting and the blood coagulating. Blood is involved in repair of a part, by extravasation and subsequent coagulation. New blood vessels form in the coagulum, which is infiltrated with blood vessels from the surrounding areas, but nerves do not have a similar ability.

The second chapter on the vascular system continues with a discussion of muscular response to stimulation. Not all involuntary muscle responds to similar stimuli. As well as muscular contraction, there is elasticity. In talking about the structure of arteries he first emphasizes the elasticity of these tissues. A piece of aorta measuring two and three-quarter inches can be stretched to three and three-quarter inches; thus it can be increased in length by rather more than a third. The contractility of arteries was then examined in a series of experiments using, among other things, the umbilical cord. Veins did not possess similar powers of contractility. He observed that the contractility of arteries arises from their muscular power and they are restored to their natural state by the elastic action. The larger arteries possess little muscular power, but as they recede from the heart towards the extremities, the muscular power is gradually increased and the elastic diminished. In middle-sized arteries, the two responses are more equally balanced. The muscular power of an artery acts chiefly in a transverse direction; the elastic power exists almost entirely in the external coat, and the muscular power in the internal coat. Arteries are furnished with both arteries and veins. The mechanical strength of vessels is weaker in proportion to size; the smaller the vessel, the weaker. There then follows a section on the heart starting with some comparative anatomy leading to the physiology and the role of its contraction and relaxation.

When a part of the body is little used the vessels supplying it become small and the part pale. Thus parts are vascular in proportion to the work they do and growing parts similarly become more vascular. They also become more vascular in inflammation. The arteries play an important role in certain diseased states, such as inflammation and fever. The flow of blood through the arterial system is maintained by valves which are attached to the inside of the vessels near where they begin and prevent regurgitation. Arteries may branch and anastomose. The total area of artery in the periphery is more than at its central origin. Veins are similar in structure to arteries, being composed of muscle and elastic; veins also have valves.

**Inflammation and repair**

In the second part of the book he passes on to the subject of inflammation. Injuries may be divided into those which do not communicate externally and those which have an external communication. The first group seldom develop inflammation, the second become inflamed and suppurate. The first stage of repair of a simple injury is coagulation of the extravasated blood. The coagulum then becomes vascular and the superfluous extravasated blood is absorbed. If a haematoma forms and needs to be opened, it may become inflamed and suppurate. The best way to promote absorbance of the coagulum is with pressure. Union by first intention takes place soon after the injury and may be firm in 24 hours, as happens with a repaired harelip or with wounds of the scalp. Simple damage may produce inflammation in proportion to the degree of damage done and this may increase the power of union of damaged parts; the inflammation may become suppurative and in this way a simple fracture may be brought to a state resembling a compound fracture.
The second group of injuries are those communicating externally; among these are gunshot wounds. Superficial wounds of this type may heal by first intention. An extraneous body, left in the wound, will promote suppuration. Where union by first intention does not take place, inflammation occurs; this is called ‘adhesive’ inflammation. If this does not happen, a third form of union occurs and this is by granulation. The inflammation that occurs before suppuration is called suppurative inflammation and is inhibitory to union of tissues. Swelling of tissues occurs throughout inflammation.

The possibility of union can occur following transplantation of tissues: the spur of a cock will grow on its comb, testicles can be transplanted into the abdominal cavity, and teeth can be transplanted into sockets of another person. This process is similar to the simple union of wounds. In this case, division of blood vessels results in effusion of blood which might result in inflammation and suppuration. However, the blood may coagulate, become dry and form a scab; this will produce union by first intention. Union may also occur by adhesive inflammation or granulation. Suppuration occurs if any extraneous substance, e.g. a ligature, is left in a wound. If the edges of wounds cannot be brought together, another method of healing is necessary.

Although the associated inflammation might cause a little pain, the act of union is without sensation. He emphasized the use of rest in healing. The formation of a scab is an important part of healing; inflammation occurs round the scab and suppuration will take place below it. Suppuration may ooze from below the scab; diminution of suppuration is a sign of resolution. Inflammation is reduced by cold but this cannot be used as a general therapy.

Inflammatory fevers were far less common in John Hunter’s time than previously; he puts this down to an alteration in mode of life and a better standard of living. There is better healing of wounds in those of a healthy constitution and less likelihood of suppuration. There is a better chance of adhesive union. Chronic diseases, such as scrofula (tuberculosis) and ague, may result in poor healing. Under these conditions adhesive or suppurative inflammation develop weakly. A severe inflammation, particularly in the abdomen, thorax or meninges, may immediately become suppurative without going through an adhesive phase. Inflammation of the peritoneum will give rise to adhesions. Ulcerative inflammation is usually a consequence of adhesive or suppurative inflammation. Adhesive inflammation brings parts together, suppurative inflammation separates parts. In disease, where it can alter the diseased mode of action, inflammation may lead to a cure; where it cannot accomplish this, it acts harmfully.

The different stages of inflammation (adhesion, suppuration and ulceration) may lead to the death of the part. Secondary effects include fever, which may lead to ‘hectic fever’, and death. The formation of adhesions may preclude suppuration; if no adhesions are formed, abscesses, fistulae and bone disease may occur.

Hunter describes an understanding of inflammation as ‘the first principle of surgery’. He defines inflammation as whatever produces pain, swelling and redness. Inflammation may arise from three types of external cause: (i) an accidental force giving rise to a wound or bruise, (ii) an irritation such as pressure, friction, heat, cold and blisters, (iii) a peculiar disposition in parts themselves, as when boils develop spontaneously. Inflammation may be divided into two kinds, healthy and unhealthy. In a gunshot wound of the thigh, inflammation will occur in relation to any extraneous matter lodged in the wound, whether the ball itself or a piece of cloth carried in.

Adhesive inflammation may vary in intensity and progress or cease; however, suppurative inflammation has little possibility of resolution. The inflammation of an abscess is more severe than that associated with an amputation or a gunshot wound. Inflammation may arise spontaneously from disease or from the death of a part arising from mechanical injury, gunshot wounds or chemical means (e.g. caustics). It may develop in bruises, and this may be quick and violent. Inflammation may also occur in febrile diseases such as smallpox, chickenpox and measles; in these, the fever is limited. Hunter believed that the fever itself produced the local inflammation but abscesses are not critical in such diseases. In plague and putrid fever or jail dis-temper (typhus) the inflammation is not healthy as with smallpox; in these cases the constitution hardly ever recovers and the patient dies.

Inflammation may be considered as a genus divided into a number of species. There are five divisions but there may be more if we take into account all the specific diseases that produce inflammation, although many may give the same appearance. As well as the adhesive with its different effects, such as suppuration, there is a second group which might be called ‘œdematous’. Another group is formed by erysipelas and the carbuncle; a further resembles chilblains which takes the form of copper-coloured blotches in the skin. Gouty inflammation differs characteristically because of the severe pain which shifts from one part of the body to another. Despite this the affected part is not as tender as in a ‘true’ inflammation.
In certain inflammatory conditions a red streak (lymphangitis) passes from the inflamed part generally towards the trunk. In oedematous inflammation there is extravasation of fluid which may be more diffuse than the inflammation itself. It may arise from inflammation acting on the dropsical state, such as an anasarca of the legs, especially after scarification. Erysipelatous inflammation is neither adhesive nor suppurative; it is commonly a secondary inflammation, usually a cutaneous condition, and will spread over a wide area; a related inflammation is that of the throat. Another similar inflammation is that which often follows scalp wounds. This inflammation extends over the head and face, creeps down both arms to the top of the fingers and attacks the body affecting both thighs, legs and feet to the tips of the toes. When it cures, the skin peels off the cured parts. As it spreads this inflammation has a determined edge. The inflammation that produces a carbuncle is stationary and circumscribed forming a broad, flat, firm tumour. It produces suppuration but differs from an abscess in that the matter lies in cells where it is formed. There may be ulceration and associated local death of tissue, a blister filled with sero-sanguinous fluid may form, and the cutis may form a slough.

The development of a red streak may arise from as little as the prick of a finger from a ‘clean’ (sic) needle. This leads to a soreness of the glands in the axilla and generalized symptoms. It does not develop in syphilis and rarely in smallpox or plague. This effect, running along the lymphatics, is not the most favourable.

**Adhesive Inflammation**

Inflammation is a condition of the smaller vessels which increase or distend beyond their normal size. The inflamed part becomes more vascular as can be seen in the frozen and thawed ear of a rabbit. This treatment excited considerable inflammation, an increase in heat and a considerable thickening of the part. After injecting and drying, the inflamed ear was more opaque than the normal ear and the arteries were considerably larger (Figure 2). This may also be observed in inflammation of the eye. The dilatation of the vessels would be related to increased relaxation of their muscular power, and the elastic power of the artery must be dilated in the same proportion. There is increased pain in the inflamed part during cardiac diastole, which is relieved by external pressure. Thus in inflammation the muscular coats of the arteries do not contract.

The colour of the inflamed part changes to various shades of red. There is also swelling due to an extravasation of ‘coagulable lymph’ and serum and the circumference of the area of swelling is oedematous. In addition, the area of inflammation is painful. Inflammation generates heat which may be local but may also be constitutional, increasing the heat of the body above the normal level. Fever may be unrelated to the generation of local heat. There is a time interval (which may be 12, 18 or 24 hours) between the event exciting inflammation and the development of inflammation. Suppurative inflammation may mix with the adhesive, or the erysipelas, kind might mix with both, leading to mortification. Strangulated hernias lead to mortification from the beginning. Here the adhesive and suppurative inflammation go hand in hand. The pericardium does not readily unite by adhesions, as a result of the development of an effusion. Adhesions do not develop between the pia and dura.
mater which become separated by suppuration. The skin may vesiculate and the epidermis often separates early in inflammation.

Inflammatory surfaces are first united by coagulated blood and adhesions then develop and become infiltrated with blood vessels. Vascularization forms the basis for the development of granulation tissue. Adhesive inflammatory tissue may degenerate and form a cyst around bullets or pieces of glass. Inflammation in the region of blood vessels may cause blood to coagulate within them, and this may lead to mortification. Hunter also noted that red blood cells from patients with inflammatory disease sedimented in serum faster than those of normal subjects.

Patients with inflammation have a quick, hard and vibratory pulse which may be full. A slow and irregular pulse can be taken as a poor sign. In association with inflammation the blood may be sизy, that is, thick and viscous.

As every inflammation has a cause, removal of the cause is a means of resolution. On treatment of a veneral disease with mercury, the inflammation will subside and with it the bubo. In many bruises and simple fractures, where there is no exposure to the outside, the inflammation is capable of spontaneous resolution. In a part that has been divided and exposed, union may be sufficient to produce resolution of inflammation. Where a scab is formed resolution may also occur. Cure of inflammation will occur when suppuration takes place. Hunter considered inflammation as the disease and suppuration only as the consequence of that disease. The disease would resolve when suppuration had supervened. Resolution is associated with a contraction of blood vessels. This may develop by producing a weakness which may be induced by bleeding and purging or constitutional agents such as sedatives and sudorifics. These however have no effect on venereal inflammations, while mercury has, nor will they resolve erysipelatous inflammation.

Bleeding should be performed with judgement as too little blood produces debility and irritability. Applying leeches to an inflamed part, as in gout, or to the temples in inflammation of the eye, has a considerable effect. The effect of bleeding is more than simply emptying the vessels mechanically, in that it excites the vessels to contract. If the coagulating lymph is long in coagulating, the red cells have time to subside and there will be a thick buff and, if the surface of the blood in the dish is considerably cupped, further bleedings may be used. If the blood coagulates weakly it will lie flat in the dish and further bleeding is contraindicated. Hunter preferred the use of leeches in certain situations, especially for local inflammation. If the pulse is hard, full and quick, bleeding may be used. However, the state of the pulse may vary according to the site of inflammation in the body. Where the pulse is small, very frequent and hard, bleeding should be performed with caution. He goes on to say that he cannot see why bleeding should have such effects on inflammation as it sometimes has. Purges are given for inflammation because, like bleeding, they lower the constitution. Preparations of bark (quinine) or lead may be used. The local effect of irritation or counter irritation is discussed; also mentioned is the application of blisters, fomentations and poultices. Adhesive inflammation occurs in wounds that cannot heal by first intention and is involved in their eventual union.

**Suppurative inflammation**

Suppurative inflammation occurs when adhesive inflammation is not capable of resolution; its immediate effect being the production of pus. Suppuration occurs if there is a prevention of union by first or second intention. It is considered that it occurs as a result of exposure to air. Suppuration does not arise simply from the intensity of inflammation or the violence of reaction, although this may give rise to mortification. However, a violent state of inflammation is frequently associated with suppuration, as following amputation of the thigh. Suppurative inflammation may terminate with a good result. Suppuration will occur more readily in internal cavities or canals, for example, if a bougie is introduced into the urethra. Suppuration is associated with a throbbing pain associated with the dilatation of arteries. This is severe when inflammation is moving from the adhesive state to the suppurative. The surrounding area that is hard in the adhesive state becomes more oedematous. Before pus is completely formed one says, 'The abscess is not yet ripe'. Constitutionally, shivering occurs. The state of inflammation that forms pus destroys the state of the parts on which it depends and they then become involved in the formation of pus. Constitutionally, the patient may be relieved by agents that induce perspiration. Wounds liable to suppurate should be kept open. The application of fomentations and poultices should be considered. Suppuration in many cases may prove fatal, for instance in the brain and meninges, thorax and abdomen.

Collections of matter similar to suppuration but without inflammation should be considered as scrofulous (tuberculous). This includes many indolent tumours, slow swelling in joints, swelling of lymphatic glands,
tubercles in the lungs, etc. Such matter is composed of a curdly substance mixed with a flaky material.

All conditions which form matter, whether or not there is inflammation, go through a phase of granulation to cicatrization. The matter may be absorbed or have to be evacuated. Absorption may take place in the absence of inflammation but not in its presence. Ulceration may occur in suppuration in the presence of inflammation; ulceration in the absence of inflammation is very indolent. An indolent lumbar abscess may produce no constitutional symptoms such as shivering. When an abscess without inflammation is opened, inflammation is excited over the whole cavity of the abscess. A perfect matter (pus) develops and constitutional symptoms such as fever supervene. This may be hectic and result in death in a very few days.

In suppurative inflammation rigors are commonly the first symptom of a constitutional affection. They are followed by a febrile period. This then passes on to perspiration, leading in some cases to resolution. If the constitution is weak a rigor may not be followed by a febrile phase, before the sweat supervenes. Constitutional effects can arise from a simple prick from a needle. Hunter believed that rigors developed from an affection of the stomach! Locked jaw was considered a similar constitutional disturbance that might arise as a result of inflammation, as also were convulsions.

Hunter was confused as to the relation between cause and effect with regard to suppuration and fever. He even asks the question, Does fever produce suppuration? Here he is probably looking for a common underlying cause for both processes. In smallpox, for instance, suppuration hardly takes place before the fever has gone. Hiccups may occur during recovery from an operation, but when it occurs at a late stage it may be a bad sign, as is delirium.

Formation of pus

The early discharge at the commencement of the suppurative state is of coagulating lymph mixed with serum as in the adhesive stage of inflammation. This then becomes whiter, yellower and eventually green. It adheres to the cut surfaces in wounds or in abscesses.

Pus was considered to develop from the dissolution of the living solids of the animal body. Another possibility considered was that pus was formed from the blood by the action of arteries. Although tendons may dissolve into pus, bone does not. An experiment was performed to see to what degree pus was capable of dissolving animal material. Muscle was divided into three portions and placed respectively in an abscess, in pus in a glass vessel and in calf’s foot jelly. That in the pus in vitro dissolved in 96 hours, whereas those pieces in the abscess and in the jelly had been reduced in weight but not dissolved. Fermentation was considered to be the cause of the dissolution but no mechanism could be thought of.

Pus consists of very small round globules swimming in a fluid, like cream. The fluid coagulates with heat like serum. It is unlike milk in that it cannot be coagulated with the juice of the stomach of animals. It can be coagulated with sal ammoniac. The thickness of the pus depends on the proportion of white globules. Pus has a sweetish taste, probably as a result of its sugar content. Pus becomes irritating to the adjoining areas with which it comes in contact, producing excoriation of the skin and ulceration. In this connection it has been called corrosive.

Pus when first discharged from an abscess is sweet. However, if the abscess has any communication with the air or if it is near the colon or rectum, or if some part of the area becomes gangrenous, it becomes putrid. Pus may also become putrid if it is mixed with blood or if there is diseased bone. Silver and lead probes become blackened in the discharge from an unhealthy sore (sulphide – similar blackening of metals may be produced by eggs). If the dressing is kept in place with leather straps, they may disintegrate. It was believed that the secretion of pus may be looked on as a general prevention of many, or all, causes of disease. It was of service to the sore in keeping it moist.

Ulcerative inflammation

Parts of the body may be progressively removed by a process of absorption or ulceration. It is by progressive absorption that matter or pus, and extraneous bodies of all kinds whether in consequence of or producing inflammation, are brought to the external surface. It is by this means that bone exfoliates and sloughs separate. The alveoli of the jaws are similarly absorbed when teeth drop out. Ulceration develops as a result of death of an external part. It is associated with sloughing, and may be observed with sloughs from caustics, bruising, mortification, etc. Ulceration may be caused by external pressure and internal pressure from an extraneous body. There is absorption of surrounding parts, as from abscesses or tumours. Whenever an abscess forms in the centre of bone an exfoliation of bone takes place and there is ulceration of the internal surface. As ulceration approaches the surface of the bone, there is adhesive inflammation of the periosteum, which Hunter calls ossific inflammation, resulting in
callus formation. This condition is known as spina ventosa in which ulceration on the inside of the bone gets worse and allows pus to escape. As an encysted tumour approaches the surface, the skin becomes thinner and inflammation occurs leading to ulceration. Progressive absorption is of two types: one without suppuration, one with. An example of pressure without suppuration is that which occurs when an aortic aneurysm presses against the vertebral column and sternum. Ulceration may be defined as absorption with suppuration. The natural consequence of suppuration in such parts is the growth of new flesh or granulations. This form of ulceration causes the type of pain known as soreness. Soreness does not usually occur with ulceration due to scrofula (tuberculosis). However, even in scrofula, soreness may occur if the formation of an ulcer is very rapid. A sore that is ulcerating may be distinguished from a sore that is granulating; an ulcerating sore is always foul. If a person is debilitated old sores may ulcerate and break out anew. Such a situation may occur in long ocean voyages; remarkable instances of this type are recorded in Anson's Voyages.

Granulations

Granulations are part of nature's way of repairing areas of inflammation. Granulations are generally associated with suppuration, but they also occur in repair when bond by first or second intention has failed, as in fractures. They form in relation to blood vessels. Few abscesses granulate before either they open by themselves or are opened by surgery. Exposure to air is necessary for granulation; a deep seated abscess will not granulate without exposure, which is why they heal poorly and often form fistulas. Granulations may form without suppuration where the breach in the tissues occurs internally, as in the union of fractures. They are very vascular and bleed freely, and have a disposition to unite with each other upon coming into contact. When the granulations are not healthy, they are not inclined to unite. Granular areas cicatrize and skin forms round the edge. Suppuration and granulation necessarily take place in wounds which cannot unite by first intention, before union and cicatrization can occur. The superficial slough scabs and falls off leaving skin which has formed under the scab. If a blister forms and the cuticle is not removed a new cuticle will form. However, if the cuticle is removed there will be inflammation leading to suppuration. In cicatrization, contraction takes place, bringing the circumference of the sore to the centre. The new cutis is never so strong as the original and is very vascular.

The effect of inflammation and its consequences on the constitution

As well as fever, there may be locked jaw, hysteria, spasm of the muscles of respiration and general restlessness which often prove fatal. Certain symptoms Hunter calls 'the hectic'. The hectic may come on at various periods after inflammation and the commencement of suppuration. The particular symptoms are debility, a small quick and sharp pulse, pallor of the skin, loss of appetite, rejection of food by the stomach, wasting, sweats and frequent bowel movements. The urine is clear. The term 'hectic' refers to the constitutional effect — the low, prolonged fever — normally associated with consumption (phthisis). These symptoms in inflammation are not just results of the absorption of pus. They attend suppuration or, in certain cases, inflammation before suppuration supervenes, as in the case of 'white swelling' of joints. Moreover, there may be situations where pus is absorbed but the patient does not become hectic. In venereal disease, a hectic state does not supervene until the condition is incurable. When a hectic state arises from a local condition, the symptoms will abate on removal of the part.

The onset of a shivering fit and loss of appetite, quick low pulse and sunken eyes precede death by a few days. The onset of tetanus is also a portent of death. Dissolution develops following bad compound fractures and amputation of the extremities, especially the lower and more particularly the thigh. It also supervenes in the hectic state. Dissolution rarely supervenes in small wounds, although these can give rise to locked jaw; however, it occurs more frequently in patients treated in hospital than in those treated in private homes and more readily in large cities than in the country. Patients with dissolution start with shivering, vomiting follows, there is oppression and anxiety and the patient has premonitions of death. There is a small quick pulse and occasionally bleeding from the whole surface of the sore. The hectic state is much slower in its progress and may be relieved by removing the local cause. The state of dissolution is not relieved by local removal.

Treatment of abscesses

Abscesses generally appear to be the result of spontaneous inflammation. There are, however, a number of causes; frequently, they are deep seated. Scrofulous abscesses, particularly, may track to a more distant dependent part. Abscesses may be classified as
sound or unsound. An example of the former is that which forms after smallpox inoculation, and may resolve spontaneously. If there is an extraneous body present this may retard healing. Sound abscesses are associated with a violent local inflammation; they ulcerate and burst. This may be encouraged by the use of poultices. The presence of exfoliated bone will retard healing and need surgical removal. In principle, an abscess should be allowed to break or open itself. If needed, an abscess should be opened where it points.

**Gunshot wounds**

Gunshot wounds include those made by musket-balls, cannon-balls and shells. Wounds of this kind result in abscesses, ulcerating bones and fistulae but may also cause calculi in the bladder or consumption from wounds in the chest. Wounds will vary according to the velocity of the projectile. On board ship, wounds may be caused by splinters of wood.

Gunshot wounds are generally contused wounds. The solid tissue round the wound may be killed and eventually thrown off as a slough. Low velocity wounds may heal by first intention. Gunshot wounds generally do not become inflamed as readily as 'accidental' wounds, especially if the missile passes through the tissues at high velocity. Where the missile fractures bone, the effect will be that of compound fracture. If the intestine is bruised when the slough comes away, intestinal contents may come out through the wound.

Gunshot wounds are attended with less bleeding than others. When the velocity is great, the direction of the ball will be in a straight line. The wound caused by a low velocity ball will heal less well because the surrounding tissues are more torn. A lower or dependent orifice heals better because of better drainage. Gunshot wounds are simple or compound. Compound wounds are associated with bony fractures, or those passing through a viscus or contained part such as brain, lungs, heart or abdominal viscera. Gunshot wounds carry pieces of clothes, etc. into the wound and these have to be removed. Those that cannot be found, such as a spent ball, will have to be left. No wound however small should be made larger unless there is something necessary to be done. Wounds should be opened only if there is tension in the area. Compound wounds are principally those which require surgery. When an artery is damaged, the vessel should be tied and this may necessitate enlarging the wound. When bone is damaged, a part may need to be extracted. Where there is a compound fracture it should be allowed to suppurate and any extraneous body should be extracted. In abdominal wounds where viscera protrude they should be replaced. When a vital part such as the brain is compressed, and vital functions are impaired, this should be relieved. Balls causing no inconvenience may be left in the body for years; in these cases the wound need not be opened if the ball cannot be found. A ball passing obliquely, and not deeply, may pass under the skin without any inflammation. Balls, particularly spent balls, may pass irregularly through the tissues. High velocity balls may be deviated by hitting bone obliquely. If the ball is felt under the skin, it should be left either to come out through a slough or to be removed surgically only when the entrance wound has healed, to reduce the risk of further inflammation. A penetrating wound of the abdomen that does not affect a viscus will do well, as adhesive inflammation will wall off the area. If any extraneous bodies, such as clothes, are carried in they will be included in the adhesions. The effect of penetrating wounds of the abdomen depend on the viscera that are damaged. Hunter advised that nothing should be done in most of these cases, especially where the intestine is wounded. In some cases fistulae may develop, and faeces may pass out of the wound which acts as an artificial anus. This may close over a period of time. The damaged intestine will be walled off by the adhesions. Penetrating wounds of the chest may not all be fatal, especially if the lungs only are affected. Bleeding from a ball in the chest is less than from a sharp instrument. Inflammation of the pleural cavity, whether suppurative or adhesive, takes place less readily than one might at first imagine. The lungs however may collapse, if adhesions are not formed, because of a collection of air or blood in the pleural cavity; this will cause difficulty in breathing. Where there is accumulation of blood in the thorax, an operation for empyema may be needed. Hunter recommended bark (quinine) and gentle bleeding as the best medicines for wounds in general, both in the presence of inflammation, and when the inflammation had gone off, if the patient is low. He looked upon bark as a strengthener and regulator of the system.

**Discussion**

Inflammation, until Hunter’s time, was considered as a specific disease defined by the four signs of Celsus, ‘redness, heat, swelling and pain’. Hunter was probably the first to recognize that there was a distinction between the causes of inflammation and the tissue
reaction. Most of his evidence is derived from clinical observation, of which he was a master. He supplements this throughout with experimental work, much of which, such as the observation on frozen and thawed ears of rabbits, is classic. However, there were some experiments which, in present times, would not be considered ethical and some from which it is difficult to draw definitive conclusions.

Although he was not completely aware of the role of microorganisms in the induction of inflammation in the clinic, there are two types of microbial disease of which he had considerable experience. These are variola and venereal infections. Hunter had a large practice inoculating patients against smallpox using material derived from smallpox lesions (Turk & Allen 1990). A number of his observations are made on the development and resolution of these lesions. Of particular interest is the temporary inhibition of the reaction by measles, probably the first description of the inhibition of a delayed hypersensitivity reaction by measles, described later by von Pirquet (1907). In his Treatise on Venereal Disease, Hunter describes an experiment in which he inoculated venereal matter from a case of gonorrhoea. There is no doubt that he considered venereal infections contagious, and he mentions rigors being caused by a simple prick of a needle. Thus he was aware that certain diseases might be transmitted along fairly definite lines. However, when it comes to the mechanism by which open wounds become inflamed, he limits himself to recognizing that this occurs as a result of exposure to air. He implies, however, that suppurative inflammations ‘...may have a principle superadded which does not alter their inflammatory mode of action, which still continues to go on. This principle is some specific disposition, from scrofula, or poisons as the venereal, smallpox etc.’ It would therefore appear that he was on the verge of recognizing the role of specific infectious agents.

As a result of his experimental work he was able to associate the redness and heat of inflammation with vasodilatation. Swelling, he indicated, was due to plasma exudation. He also made the point that pain varied with the nerve involved. He divided inflammation into three categories of increasing severity: adhesive, suppurative and ulcerative. This subdivision was based purely on clinical observation. Much of what we now know as inflammation he put into the category of adhesive inflammation. This covered the causation of abdominal adhesion and much of what, in the antibiotic era, we call wound healing. However, it also covers Hunter’s own work on transplantation. He included the mechanism by which grafted tissues and organs join onto the normal tissues under the action of an adhesive inflammatory reaction. He implied that the transplanted tissue evoked the inflammatory reaction and the tissue response which caused the transplanted tissue or organ to adhere to the normal tissue. Naturally he had no knowledge of the difference between autologous or foreign (such as allogeneic or xenogeneic) grafts but one might find an inkling of the similarity between the reaction to foreign grafts and other inflammatory reactions, particularly those of the cell mediated immune type.

In his section on gunshot wounds, he particularly emphasizes the fact that these wounds were likely not to cause as much inflammation as other wounds. Musket balls caused less bacterial contamination unless they carried clothing, etc into the wound and the heat of the musket balls must have affected bacterial contamination.

Hunter was aware of the difference between collections of pus caused by mycobacteria and by other organisms. He states that suppuration without inflammation should be considered as scrofulous. However, whenever an abscess without inflammation is opened, inflammation develops and fever supervenes. This is because of contamination and infection with pyogenic organisms that are generally associated with the development of an inflammatory reaction.

It is of interest that patients fighting infection caused by pyogenic organisms develop similar constitutional disturbances to those with chronic tuberculous infections. The ‘hectic’ fever that occurs is classically the fever developed by patients with pulmonary tuberculosis. Are we dealing here with endogenous pyrogen or interleukin-1 released from macrophages infiltrating both types of lesion? The other constitutional disturbance that he mentions is locked jaw or tetanus. Contamination of wounds with Clostridium tetani and release of tetanus toxin must not have been uncommon in Hunter’s practice. The roads were heavily contaminated with manure and this condition, which is now considered to be a rural problem, must have been as much an urban problem in Hunter’s day.

Hunter’s classification of inflammation was very influential in the nineteenth century. He is quoted by Virchow (1858) and extensively by Paget (1853). Lister openly acknowledged that he had been influenced by the tradition started by Hunter (Godlee 1924). Paget (1853) even includes an engraving of the rabbit’s ears in Hunter’s collection, the subject of the experiment quoted in this treatise. Hunter’s contribution to the pathology of inflammation is still being quoted in the latter part of this century (Lewis 1986).
References
