

PILONIDAL SINUS

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A pilonidal sinus is one containing hair and, although the condition is most often thought of as a sinus in the mid-line in the sacrococcygeal area, numerous reports have been published of similar sinuses elsewhere in the body. It was probably the realization that the condition did occur in other anatomical regions that stimulated further investigation into the aetiological factors concerned. However, the absence of these lesions until adult life, their multiple nature in some cases, their occurrence at various sites (as in the webs of fingers of barbers, and in the perineum and axilla), and the absence of growing hair in the sinus, gave rise to reasonable doubt whether the lesion had a developmental origin.

The main purpose of this communication is to indicate a modified method or primary suture which has been successful in 20 cases. The literature on the aetiology, pathology, diagnosis and treatment is also reviewed.

The theories concerning the origin of pilonidal sinuses fall under the opposing headings of congenital and acquired.

THEORIES OF CONGENITAL ORIGIN

Embryology¹⁻³ The primitive streak is formed in the 2nd or 3rd week of foetal life. Shortly afterwards a fold appears on each side of it and the medullary (or neural) groove is formed between the two folds. These folds develop slowly and incline towards each other in the dorsal mid-line until fusion takes place. This converts the neural groove into a canal, which becomes the central canal of the spinal cord, and the cells surrounding it become the central nervous system of the full-term foetus. During this process of development the spinal vertebrae are forming from primitive mesoderm. The medullary canal closes first in its cranial part and spreads downwards to close finally at its caudal end.

Unequal growth at the distal end of the spinal column induces a bend in the form of a loop. A connection remains between the skin and the distal end of the cord. This connection gives rise to masses of cell nests which contain cavities lined with pavement epithelium. Normally these cords disappear by the 6th month.

(a) Neurogenic

Hermann and Tourneaux⁴ in 1887 and Mallory⁵ in 1893 supported the view that, after separation of the spinal cord from the superficial tissues, a process of epithelial tubes persists for a time at the point of previous connection of the neural axis with the skin, forming a vestigial remnant of that connection.

Gage,¹ from observations of serial sections of embryos, substantiated the neurogenic basis for these abnormalities and concluded that pilonidal cysts form from the medullary vestiges and the dimple from the attachment of the caudal ligament.

Sinuses communicating with the vertebral coverings of the sacral canal have been reported.⁶ It was stressed that meningitis was a common and early sequel of this abnormal condition, but Aird⁷ and Kooistra⁸ both point out that the opening in the spinal cord is usually at a higher level than in the case of a pilonidal sinus.

Oehlecker⁹ held that in the early embryo the lower three or four vertebrae disappear and become the caudal ligament, which is attached to the skin. As the caudal vertebrae undergo rapid growth, the overlying skin is unable to maintain the same rate of growth, and is displaced upwards and posteriorly drawing with it the tip of the caudal ligament. By the 4th or 5th month, the skin which originally covered the tip of the coccyx lies over the 3rd and 4th caudal vertebrae; this site is thin, hairless and vascular and is called by Oehlecker the 'sacral bald spot'. The caudal ligament is attached to the skin, exerts a pull on it, producing a depression, the coccygeal dimple.

(b) Ectodermal Invagination

Fox⁹ studied serial sections of embryos and refuted the neurogenic theory. He maintained that faults in the process of hair and gland development give rise to cysts, and that the forerunner of the

pilonidal sinus in man may be a specialized and transient skin appendage, the function and homologues of which in other species are as yet undetermined.

Stone^{10,11} believed that the sinus is the result of a special down-growth of epithelium from true skin, and not from the medullary groove; he compared this structure with other organs formed by special downgrowths, such as the breast and the external ear. He later allied this sinus to the preen gland (*glandula uropygii*) of many species of birds, a multitubular gland embedded in the subcutaneous fat over the lowermost caudal vertebrae, whose tubules converge and empty through an epithelial-lined duct to the skin of the back.

Newell¹² believed that the pilonidal sinus is a dermoid fistula, but differing from a true sequestration dermoid in that it is caused by traction of the underlying tissues upon the median raphe. This traction is probably caused by the retrogression of the tail bud and the structure could therefore be described as a traction dermoid. He postulated that an epithelial-lined fistula is present at birth, and may remain for a time without giving rise to symptoms. With the growth of the body and enlargement of the buttocks, the secretion of this epithelium is unable to escape by the orifices in the mid-line, and retention of secretion may result in sepsis followed by an abscess.

Haworth and Zachary¹³ discuss 11 cases of pilonidal sinuses in infants presenting with symptoms, 3 of which communicated with the spinal canal. In an additional 7 cases pilonidal sinuses were found as an associated condition amongst 500 infants attending an out-patient department. They are of the opinion that all pilonidal sinuses are congenital, and that only in adult life do they produce symptoms because of obstruction to the opening of the sinus by hairs.

Objections

The congenital theory fails to explain the following difficulties:

1. That hairs in the sinus lie free.
2. That no one has yet confirmed the presence of skin appendages in the lining deep to the opening on histological section of the sinus in the adult.
3. The rarity of the condition in Africans, in whom, when it does occur, is seen more commonly in females.
4. The rare occurrence of sinuses or cysts in children.

THEORIES OF ACQUIRED ORIGIN

Warren¹⁵ in 1854 and Hodges¹⁶ in 1894 held that pilonidal sinuses may be produced by constant pressure, explaining that body hairs broken off by friction in a pilous region may become matted together and lodge in a depression, and in the course of time excoriate the surface softened by continuous perspiration and penetrate the integument, finally provoking inflammation and suppuration. Brearley¹⁷ and Patey and Scarf^{18,19} also suggested that these sinuses were acquired.

Brearley,¹⁷ drawing from his own cases and those of Patey and Scarf, suggested the following cause: In most of the sites where a pilonidal sinus occurs there are nearly always two opposing flat surfaces producing a rolling movement. This twists the hair into a bundle and drills it obliquely through the skin. Once this has happened, suction plays a part. In the buttocks this is produced by the fact that the skin is attached to the deep fascia, and any force which draws the skin laterally across the buttocks puts tension on this fascial attachment and thereby creates a suction force. Brearley was able to measure pressure by inserting a needle into the subcutaneous tissue of the gluteal cleft and connecting it to a manometer filled with saline.

Brearley explains the age incidence of pilonidal sinus by the fact that only after puberty do stiff body hairs appear, and after middle age the hairs soften and those who are likely to have suffered from the condition would have already acquired it. The preponderance in men (see below) is explained by the existence of more stiff body hairs in males.

He ascribes the rarity of the condition in Negroes to the fact that they have less body hair and that what they have is curly and ill-adapted to having a drilling effect.

Patey and Scarf²⁰ give a reasoned explanation for the presence of hairs in the sinus with their roots lying deeply. The scales of a hair are so arranged that their free ends point peripherally. As a result, if a hair is stroked along its surface from the root to the periphery there is little movement of the hair, because of its slight frictional resistance. If, however, a hair is stroked from the periphery to the root there is considerable frictional resistance from the free ends of the hair scales and the hair is propelled in the direction of its roots. This can readily be confirmed by placing a hair in the palm of the hand and rubbing to and fro with a finger of the other hand.

In the natal cleft, therefore, shed hairs will tend to lie longitudinally owing to the configuration of the cleft. The normal frictional movement between the sides of the cleft will propel the hair either cranially or caudally, according to the direction in which the roots of the hair happen to be pointing. If a dimple or pit is present many of the cranially propelled hairs will enter its orifice, invariably root first. The same forces will resist the expulsion of the hairs and tend to force their roots still further into the depths of the sinus. They also drive an infected hair into the intact skin and thus initiate a pilonidal sinus.

PATHOLOGY, AETIOLOGY AND CLINICAL FINDINGS

The majority of cases in the present series were infected, and in only one case could the findings of serial sections of an infected track be seen.

There is always a primary track; it most commonly has an opening in the mid-line but occasionally this may be to either side. In this series, however, the majority opened to the left side rather than in the mid-line. There may be multiple primary openings but they all open into the main track in the mid-line. The track runs upwards and anteriorly.

Hairs may be seen lying free and protruding through the sinus opening but, as most of the cases in this series were infected or had been treated before, free hairs were seen in only one case.

Histologically, sections of the one non-infected case confirmed Aird's statement⁷ that the first few millimetres were characteristic of the skin, with epithelial lining, but beyond this the lining was of granulation tissue. No hair follicles, sweat glands or sebaceous glands were seen in the sections.

Both Brearley¹⁷ and Patey and Scarf^{18,19} failed to find evidence of skin appendages in the sinus track of the cases they sectioned.

Pilonidal sinus is found predominantly in young, dark, hairy, adult males. Males are affected more than females in the ratio of 7 to 1. It is rare among Negroes, but by no means uncommon among Indians. A total of 77,600 soldiers were admitted to U.S. Army Hospitals for pilonidal disease from 1942 to 1945.²¹

Occupation may play a part and Buie^{22,23} thought it such a common factor that he named it 'jeep disease', supposing that the trauma from the continual jolting acted as a sort of percussive force and assisted penetration of hairs in susceptible subjects.

It is very rare to have a patient present without symptoms, but the condition may be a coincidental finding. In nearly every case, the predominant symptom is recurrent abscess and associated pain in the coccygeal area. Occasionally it may be very difficult to find a sinus opening but with patient probing the sinus opening can always be established. Fine hairs may be seen protruding from the sinus opening, particularly in cases seen for the first time. One patient in this series, a young university student (White male) showed this very clearly (Fig. 1).

Systemic symptoms are very rare and, unless a very



Fig. 1. Tuft of hair shown protruding through sinus opening. Note also marked hirsutism.

extensive cellulitis has resulted from the abscesses, pyrexia, nausea and vomiting are, indeed, a rarity.

Diagnosis and Differential Diagnosis

A history of recurring pain and discomfort in the sacro-coccygeal region, frequently with a discharge, is very suggestive.

In the acute stage an ischio-rectal abscess may be mistaken for a pilonidal, but the former usually presents a definite systemic reaction. The origin of an ischio-rectal abscess is almost always within the anorectal canal, and the abscess itself is merely a stage in the development of an anorectal fistula. From its position and tenderness in the anal or rectal canal, and the discovery of an internal opening at or near the anorectal line, the diagnosis is clear.

A fistula-in-ano is shown by probing, proctoscopy and sigmoidoscopy. It should be noted that the mid-line pilonidal sinus always goes deep and cranially. Boils, carbuncles, infected sebaceous cysts, seldom give the characteristic prolonged history, nor that of repeated attacks. Other conditions to keep in mind are osteomyelitis and tuberculosis of the sacrum, which can be ruled out by X-ray examination. Actinomycosis may occur in this area and is to be excluded by bacteriological examination.

Inclusion dermoids, chordomas, teratomas and other neoplasms have to be considered. In the great majority of cases of pilonidal sinus careful search will reveal one or more characteristic mid-line openings, and if hair, as in the occasional case, is seen protruding from the sinus it will make the diagnosis obvious.

TREATMENT

Various methods of treatment have been proposed, which is testimony to the fact that no one procedure is outstandingly successful in avoiding morbidity and recurrences. No single technique can be laid down but the treatment must be suited to the local condition.

Swinton²⁴ raises a very important point when he states that a common pitfall is to regard the treatment of a pilonidal sinus as a minor surgical procedure; it is far from being an insignificant surgical problem. How true is the following note of warning:²⁵ 'All methods of dealing with pilonidal sinus have in common the grim determination of their originator to make them more effective, and by dint of exceptional care with the operation, or—in open operations—with the

dressings, better results are obtained. It is extraordinary that so simple a lesion should tax the surgeons' ingenuity, but it is about time to admit the fact that what it taxes is not the adequacy of the method employed, but how well, how carefully, and how gently the surgeon executes it'.

In the treatment sufficient attention is often not given to basic surgical principles. Proper sterilization of the skin and depilation of the area before the operation, elimination of all dead space and complete haemostasis, prevention of infection and avoidance of tension, and finally rest in bed until the skin wound is healed, are all essential.

Proper planning must be the primary consideration. If more than one sinus exists, all are to be probed to see their connection with the main sinus.

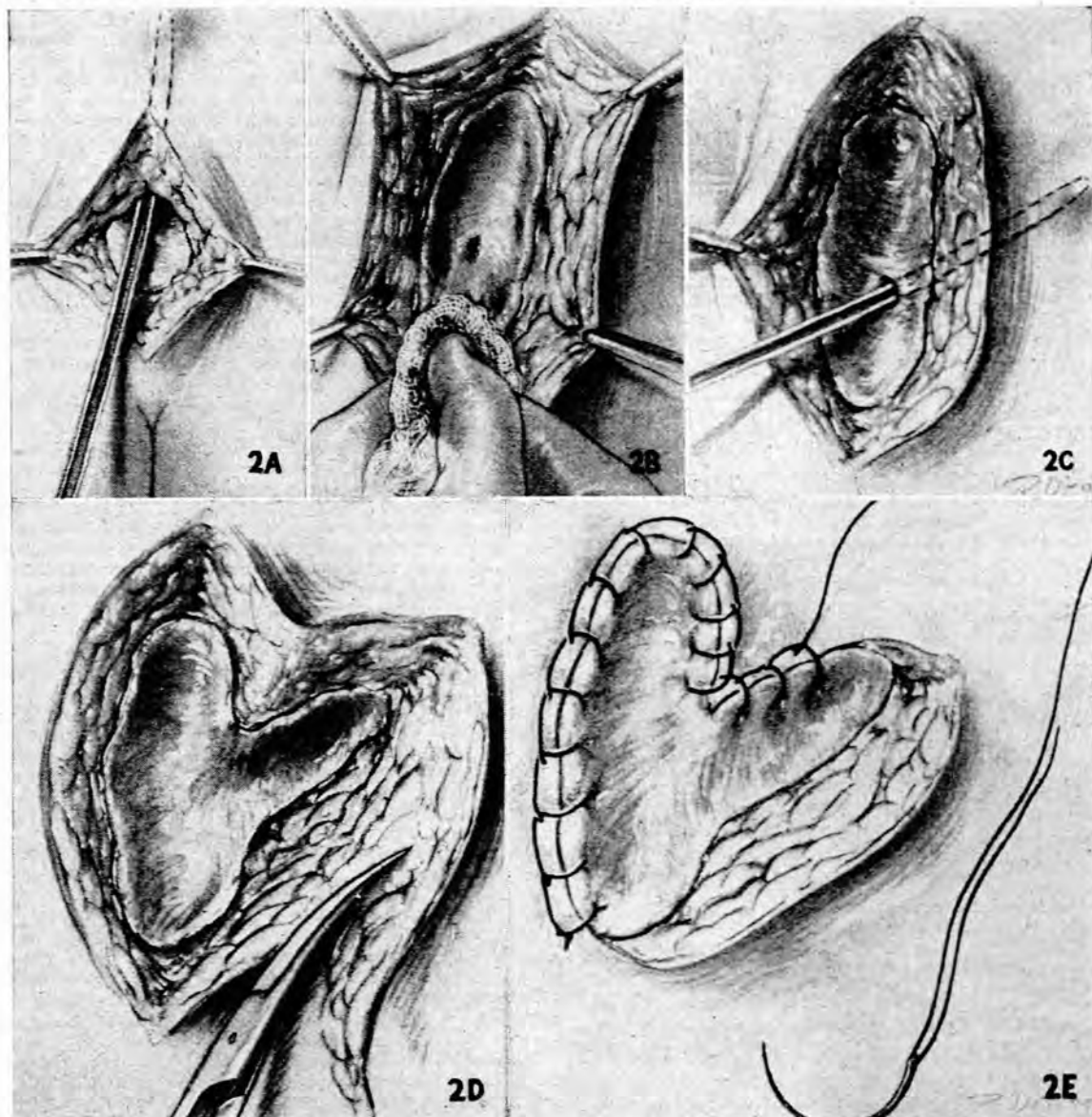


Fig. 2. From Buie, L. A. and Curtiss R. K. (*Surg. Clin. N. Amer.*, August 1952, p. 1247). Artist, Drake, R.

2A. The pilonidal sinus has been incised partially. A grooved director is in place.

2B. The wall of the abscess has been scrubbed and a subsidiary tract is revealed.

2C. Grooved director inserted in subsidiary tract.

2D. The wound is being trimmed so that the margins of the skin can be made to fit the edges of the scar.

2E. The application of a continuous lock stitch marsupializes the wound.

Should there be multiple sinuses that can be incorporated in a transverse incision, there can be no objection to such an attack if it avoids massive excision of healthy tissues.²⁶

Pulaski²⁷ studied 157 cases and concluded that antibiotics play a minor role and that a permanent cure is dependent on careful attention to fundamental surgical principles.

Before the surgical problem of the chronic or recurrent pilonidal sinus is considered, reference should be made to the case presenting with an acute abscess. This presents no problem. It should always be drained, and the incision should be so designed as not to interfere with the definitive treatment at a later date. A block excision of the inflamed mass is contra-indicated.

THE CHRONICALLY INFECTED PILONIDAL SINUS

The definitive treatment in these cases can be discussed under the following headings: (1) conservative, (2) the open method, (3) the closed method.

1. Conservative Method

This was developed by Hardaway,²¹ of the U.S. Army, because of his dissatisfaction with the results of operative treatment. The entire intergluteal area is shaved every 4 to 5 days; all hair is removed from the sinus opening and kept out. Sedulous personal hygiene is observed, with thorough daily soap-and-water cleansings of the intergluteal area. Hexachlorophene detergent should be used if possible. After defaecation the anal area is cleansed with the movement away from the intergluteal region. The area is kept as dry as possible. The patient is advised not to drive a vehicle.

Other non-operative methods have been employed, such as sclerotherapy²⁸ and electrotherapy, but have not proved very successful.

2. The Open Method

This can be performed either by liberal excision or with the cautery.

Excision by hot cautery has been performed by Rogers.²⁹ An incision is made in the mid-line through the cyst down to the fascia covering the sacrum and coccyx. The cyst is excised in two parts and the wound packed with petroleum gauze. The dressing is changed every second day and replaced by iodoform gauze, eusol, or saline dressings, according to the amount of discharge present.

The objection to the open method is the long delay in healing, with resultant long hospitalization; and follow-up on patients so treated showed that at least 10-15% required further surgery because of a discharging mid-line sinus. It should not be overlooked that these patients suffer a great deal of post-operative discomfort and great pain; they are also a very trying nursing problem, requiring constant attention and repeated change of dressings. The average healing time is 8-14 weeks.

To overcome this, a method of marsupialization has been evolved, first described by Buie.²² Lawrence and Baker³⁰ give details of 120 cases treated in this way. The sinus, including any lateral extensions, is laid open and chronically infected granulation tissue and hair nests are curetted out. The skin edges are then sutured to the lateral margins of the scar-tissue bed of the sinus in such a way that the wound is converted into a saucer with the fibrous wall of the cavity exposed only at the bottom. The wound is usually a quarter of the size of the wound produced by excision and therefore healing time is more than halved (Fig. 2, A-E).

3. Excision with Primary Closure

The method now to be described was used in 20 cases in the present series, both White and non-White. All these patients underwent excision of their sinuses with primary closure, and they were all healed in 14 days. In a follow-up of from 3 to 18 months none have shown evidence of recurrence.

Pre-operatively the skin is prepared as for an orthopaedic operation. Pubic, perineal, sacral and anal hairs are shaved over

a wide expanse. In 2 cases pre-operative depilation doses of X-rays were given. If any discharge is present, swabs are taken for culture and sensitivity tests carried out; and a suitable antibiotic is commenced on the day before operation and continued for 7-10 days afterwards. The patient is placed on a low-residue diet 2 days before operation and this is continued for 12 days after the operation.

General anaesthesia was used in every case. The patient was placed prone, with a pillow under the pelvis and in a slight head-down and leg-down position so as to make the sacrococcygeal area more prominent. Elastoplast was then fixed to each buttock and traction applied to open up the gluteal cleft. The strapping should be well beyond the field of operation so that later contamination may not occur. The operative field is now thoroughly prepared for operation. Care is taken to exclude the anal region from the operative site.

An elliptical incision is made, starting in the mid-line approximately 1½-2 inches above the sinus opening and usually including 1-1½ cm. of healthy skin on either side of the main sinus. The two limbs of the ellipse meet again in the mid-line, approximately 1½-2 inches below the sinus opening. Lateral extensions to take in secondary sinuses are in the form of wedge extensions off the main incision. The proximal part of the ellipse is first freed and grasped in a Lane's tissue forceps, and the incision is deepened on either side through fat, down to the glistening sacral fascia, in the meantime lateral traction being maintained on the edges of the wound. As the incision on either side deepens and extends caudally, more Lane's tissue forceps are applied to the freed tissue and, by manoeuvring the elevated tissue from side to side, freeing of the block of tissue is facilitated. At the lower pole, care is taken not to approach too near the anal region. As the distal part is freed and deepened, another Lane forceps grasps this end and, with firm traction on all the forceps, it is a very simple procedure to free the whole block of tissue. After excision, a hot saline pack is introduced into the cavity and firm pressure applied for 5-10 minutes. Where necessary the cautery has been preferred for bleeding points.

The glistening fascia below reveals that the sinus has been adequately removed. Search is made for further sinuses and any small pocketing in the depths of the wound is adequately dealt with.

With a large curved cutting needle threaded with long medium-strength nylon, the first suture is inserted at the top end of the wound, approximately 1½ inches from the edge of the wound. The stitch is so inserted as to penetrate through gluteal fascia on the same side down to the sacral fascia and across to the gluteal fascia on the opposite side. The stitch is then made to return so as to produce a figure-of-eight and emerges on the same side at a distance of about 1 inch above its original insertion (Fig. 3A).

The ends are left long and separated, with artery forceps on each end. A similar stitch on the opposite side is introduced, which interlocks with the stitch first inserted (Fig. 3A). Three such pairs of stitches on each side are usually inserted. Penicillin and streptomycin powder is then dusted into the wound after haemostasis has been assured. The elastoplast strapping is then cut so as to let the buttocks appose and evaginating interrupted mattress sutures of black silk are carefully inserted and tied so as to accurately approximate the skin edges (Fig. 3B).

A large snugly-fitting gauze roll (specially prepared by rolling gauze swabs together in the form of a sausage) is then laid down the length of the sutured wound (Fig. 3B), and a similar sized gauze roll is laid across this one at right angles to it, starting at the proximal end first. This gauze roll is kept in position by tying the nylon strands firmly over the roll at its two lateral ends, care being taken that each corresponding pair of nylon sutures are tied. This has the effect of reducing the dead-space by drawing the gluteal fascia together. Two similar rolls are laid across parallel to the transverse-lying roll and similarly tied (Fig. 3C).

The patient is returned to the ward and placed flat in bed in a supine position with one head pillow. On regaining consciousness he is instructed to remain in this position and, although the wound area is tender, there is slight discomfort for the first 48 hours, and only one or two post-operative injections of pethidine are required in most cases. It is felt that by lying in this position further obliteration of the dead-space by pressure is obtained.

Tinct opii (10 minims) is given to keep the bowels costive, and low-residue diet without milk is continued. The antibiotic given

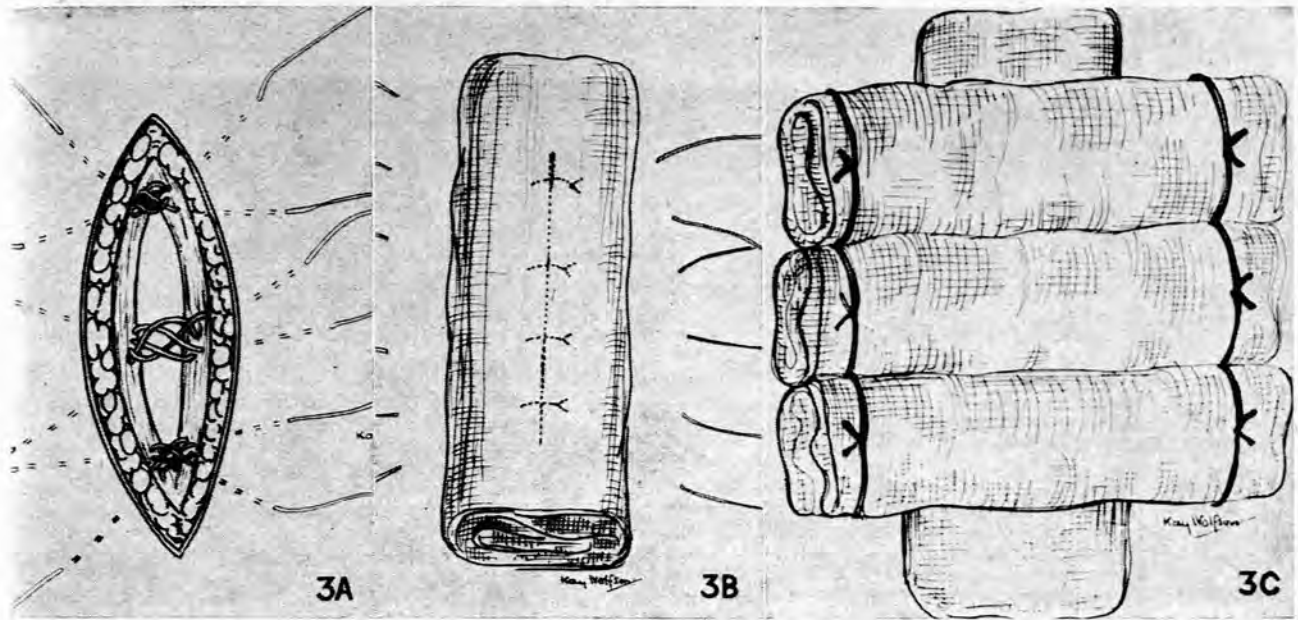


Fig. 3. Method of suture of wound after excision of sinus.

A. Shows figure-of-eight sutures (thick nylon) passing through skin and gluteal fascia on same side, picking up gluteal fascia on the opposite side, and returning to same side as entering suture.

B. After figure-of-eight sutures inserted, skin apposed with six sutures and first longitudinal roll of gauze applied.

C. Horizontal gauze rolls now applied and figure-of-eight sutures tied over end of each horizontal roll.

before the day of operation is continued for 10 days. The patient is not allowed up, and remains recumbent for 10 days.

Although some of the patients complained of abdominal discomfort because of constipation, in no case did it require any alleviation or treatment. A close watch is kept on the temperature chart and the dressings are examined each day by rolling the patient over. In no case was it necessary to remove the dressings until the 14th day. Every case healed by primary intention, and in only one case was a mild degree of sepsis present in the lateral stitch wounds, which quickly responded to saline dressings.

Attention to fundamental surgical principles has given good results. To this must be added the fact that the chance of soiling from faecal contamination is eliminated as far as possible and plays a very important part in the prevention of infection.

SUMMARY

1. The various theories of the formation of a pilonidal sinus are presented. A combination of both acquired and congenital factors appear to play a greater or lesser part in any one case.

2. The histopathology is considered, which tends to support the role of an acquired factor.

3. The diagnosis and differential diagnosis is discussed.

4. The various methods of treatment are described and, finally, a particular operative method is presented in detail.

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ADDENDUM

Since the time of writing a coincidental finding of a sinus over the sacrococcygeal area was made in a male child 6 weeks old,



Fig. 4. See text.

who was admitted to a children's medical ward for gastro-enteritis. Fig. 4 shows the sinus clearly in the characteristic position. The mother said that no secretion or discharge had ever emanated from the sinus opening. The child was otherwise perfectly normal. Both lower limbs were carefully examined to rule out any lesion of the central nervous system, and X-rays revealed no evidence of spina bifida or agenesis of the sacrum. Probing under strict aseptic conditions showed that the sinus extended upwards for a distance of 1.5 cm. and ended at the spinal column.

No specific treatment has been instituted at the moment but it is hoped to follow the case as an out-patient and to excise the sinus at a later date.

The lesion is certainly what Haworth and Zachary¹³ describe as a congenital sacrococcygeal dermal sinus, and supports their contention that pilonidal sinuses at this site—discovered later in adults—may be developmental in origin.

REFERENCES

- Gage, M. (1935): *A.M.A. Arch. Surg.*, **31**, 175.
- Arey, L. B. (1946): *Developmental Anatomy*. Philadelphia and London: Saunders.
- Berkowitz, J. (1949): *Amer. J. Surg.*, **77**, 477.
- Hermann, G. and Tourneaux, F. (1887): *J. Anat. (Paris)*, **23**, 498. Quoted by Stone, *loc. cit.*¹¹
- Mallory, E. B. (1893): *Amer. J. Med. Sci.*, **103**, 269.
- Kooistra, H. P. (1942): *Amer. J. Surg.*, **55**, 3.
- Aird, I. (1957): *Companion in Surgical Studies*, Edinburgh: Livingstone.
- Oehlecker, F. (1926): *Dtsch. Z. Chir.*, **197**, 262. Quoted by Berkowitz, J., *loc. cit.*³
- Fox, S. L. (1935): *Surg. Gynec. Obstet.*, **60**, 137.
- Stone, H. B. (1924): *Ann. Surg.*, **79**, 410 (quoting Streeter).
- Idem* (1931): *Ibid.*, **94**, 317.
- Newell, R. D. (1933): *Brit. J. Surg.*, **21**, 219.
- Haworth, J. C. and Zachary, R. B. (1955): *Lancet*, **2**, 10.
- Willis, R. A. (1958): *The Borderland of Embryology and Pathology*. London: Butterworth.
- Warren, J. M. (1854): *Amer. J. Med. Sci.*, **28**, 113.
- Hodges, R. M. (1880): *Boston Med. Surg. J.*, **103**, 445.
- Brearley, R. (1956): *Brit. J. Surg.*, **43**, 62.
- Patey, D. H. and Scarf, R. W. (1946): *Lancet*, **2**, 484.
- Idem* (1948): *Ibid.*, **1**, 378.
- Idem* (1955): *Ibid.*, **1**, 772.
- Hardaway, R. M. (1958): *A. M. A. Arch. Surg.*, **76**, 133.
- Buie, L. A. (1944): *Sth. Med. J. (Birmingham, Ala.)*, **37**, 103.
- Buie, L. A. and Curtiss, R. K. (1952): *Surg. Clin. N. Amer.*, **32**, 1247.
- Swinton, N. E. and Markee, R. K. (1953): *Amer. J. Surg.*, **86**, 562.
- Editorial (1953): *New Engl. J. Med.*, **249**, 926.
- Kleinman, A. (1950): *Surgery*, **28**, 851.
- Pulaski, E. J. *et al.* (1956): *Ann. Surg.*, **144**, 170.
- Cutler, E. C. and Zollinger, R. (1933): *Amer. J. Surg.*, **19**, 411.
- Rogers, H. (1944): *Milit. Surg.*, **95**, 454.
- Lawrence, K. B. and Baker, W. J. (1951): *New Engl. J. Med.*, **245**, 134.