Papers on Surgery by M L Kothari et al

Sl.No.	Description	Journal	Co-Contributors
1.	Observation in clinical surgery	Journal of J J Group of Hospitals and Grant Medical College	None
2.	THE USE OF A SILICONE RUBBER SPLINT FOR POST-VASECTOMY VAS DEFERENS ANASTOMOSIS: REPORT OF A NEW OPERATIVE TECHNIOUE		D S Pardanani, M N Mahendrakar and S A Pradhan
3.	Metronidazole in Dracunculosis	Journal of Indian Medical Association	D S Pardanani
4.	Management of Dracontiasis	Post Graduate Journal of Medicine	D S Pardanani, M P Anand, Lopa Mehta and D L Kothari
5.	NIRIDAZOLE IN DRACONTIASIS: A CONTROLLED STUDY	Transaction of the Royal Society of Tropical Medicine and Hygiene	D S Pardanani, Lopa Mehta and D L Kothari
6.	Dracontiasis in Man: Biology of the Worm and Pathology of Lesions	Indian Journal of Surgery	D S Pardanani, M P Anand, Lopa Mehta and D L Kothari

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OBSERVATIONS IN CLINICAL SURGERY

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(I) A Method of measuring Fixed Adduction-Abduction Deformities of the hip joint :

Whenever there is fixed adduction or abduction deformity of the hip joint, it is concealed by a compensatory tilt of the pelvis upwards or downwards on the affected side. Such a tilt presents a limb that appears normal in position (i.e. parallel to the normal limb) but which exhibits apparent shortening or lengthening, respectively. Such a deformity is usually measured by adducting or abducting the affected limb till the anterior superior iliac spine on the affected side comes to the same horizontal level as the spine

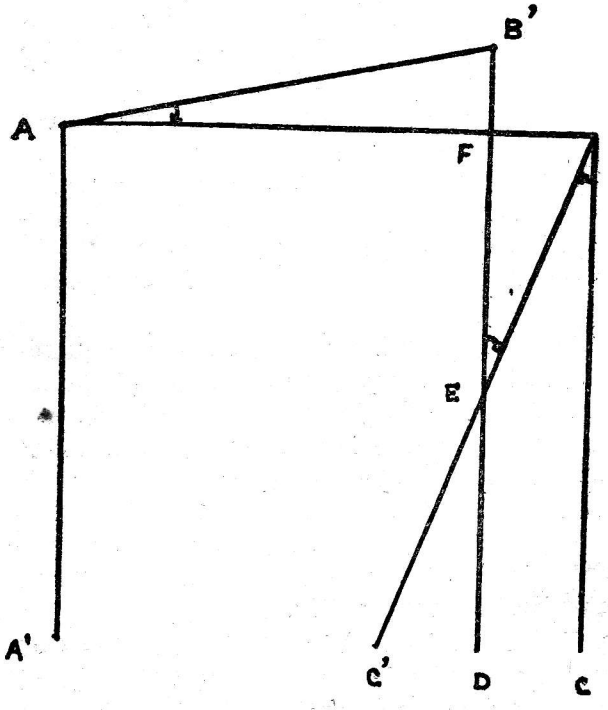

Fig. 1

LEGENDS

Fig 1: Diagrammatic explanation of the suggested method.

A and B are the two anterior superior iliac spines and AA' and BC the two lower limbs in their normal position. For the sake of convenience, the lower limbs are considered in relation to the anterior superior iliac spines and not to the hip joints proper. B' is the position of the left anterior superior iliac spine when the pelvis had tilted upwards to compensate for the fixed adduction deformity (CBC') of the left hip. B'D is the position of the left lower limb in the compensated position so that B'D is parallel to BC.

∠B'AB is, therefore, the angle of fixed adduction according to the new method suggested; whereas ∠ C'BC is the angle of fixed adduction when measured by the conventional method. It is to be shown that ∠ B'AB = ∠ C'BC.

Proof: ∠C'BC = ∠ B'EB (alternate angles).

In triangles AB'F and BEF

∠ AB'F = ∠ FBE

∠ F is common

∴ ∠ B'AB = ∠ B'EB = ∠ C'BC

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on the normal side. The arc through which the limb had to be moved measures the angle of fixed adduction or abduction.

A method which is simpler and obviates any manoeuvre on the patient is suggested as follows: Do not disturb the compensation. Join the two anterior superior iliac spines (AB' in Fig. 1). From the spine on the normal side, draw a line horizontally towards the normal position of the opposite spine (AB). Then the angle between these two lines (BAB') measures the angle of fixed adduction. Alternatively, join the two spines (AB') and drop a perpendicular from the spine on the normal side (A) to the median vertical line. The angle between these two lines measures the angle of fixed adduction. By drawing imaginary lines as described above, it is possible to obtain the angle of deformity on inspection alone.

A geometrical proof (Fig. 1) showing that the angle measured by the method suggested is equal to the one measured by the conventional method is presented. The method is equally useful for measuring fixed abduction deformities of the hip joint.

(II) An Inspection sign for Swellings in the Inguino-scrotal Region and the Groin :

While dealing with a swelling in the inguino-scrotal region, it is customary for the clinical teachers and the books on Clinical Surgery to insist on "reaching the top of the swelling on palpation" to decide the nature of the swelling, viz. inguinal, scrotal or inguino-scrotal.

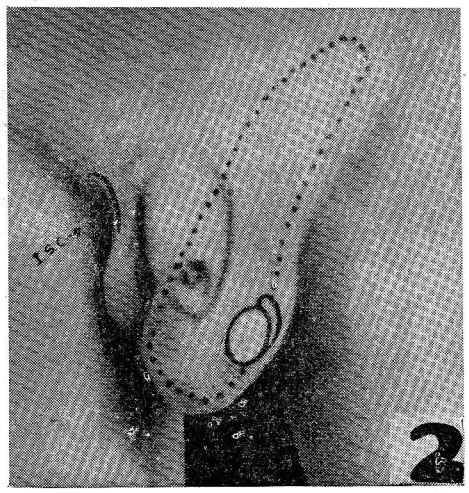
By observing the nature of, what I would call, the inguino-scrotal curve, this could be decided on inspection alone. The inguino-scrotal curve, in the normal (Fig. 2) begins at the top of the convexity of the scrotum as a line which has its convacity directed first outwards and then outwards and downwards before merging with the inguinal region on either side. The curve remains unaltered in swellings purely inguinal or scrotal (Figs. 3-4). In case of an inguino-scrotal swelling, however, the concavity of the curve is flattened out or is replaced by a manifest convexity (Fig. 2).

It is also possible to diagnose a femoral hernia from an inguinal hernia on inspection. In the case of a femoral hernia, a line traced downwards and inwards along the outer margin of the swelling has no continuity with the inguino-scrotal or the inguino-labial curve but forms an acute angle (inguino-femoral recess) with the curve (Figs. 5-6).* Such a line in the case of inguinal herniae, falls in continuity with the inguino-scrotal or the inguino-labial curve (Figs. 3-7). The inguino-labial curve is represented, in the normal, by the outer margin of the labium majus.

(III) A Preliminary Report on Observations in cases of Silent Abdomens :

While examining a series of silent abdomens (peristaltic quiescence following peritonitis or a laparotomy), it has been ob-

* Vide Text-book of British Surgery Vol. I (1936) fig. 170 showing bilateral femoral herniae.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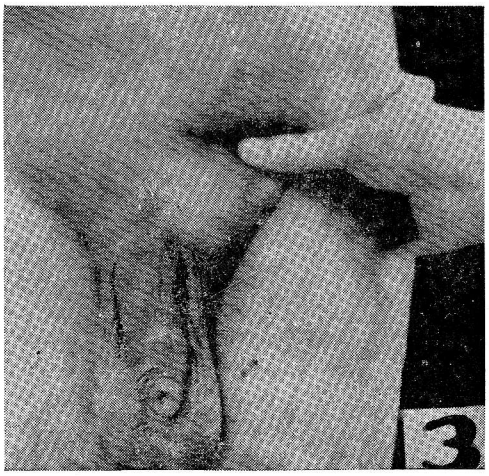
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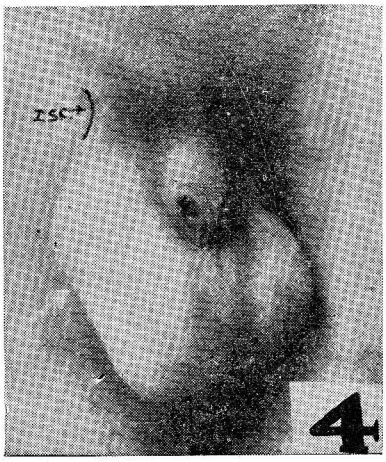
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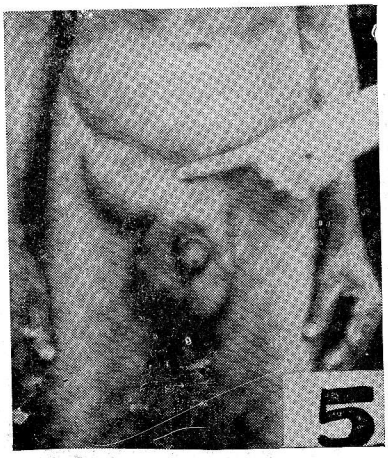
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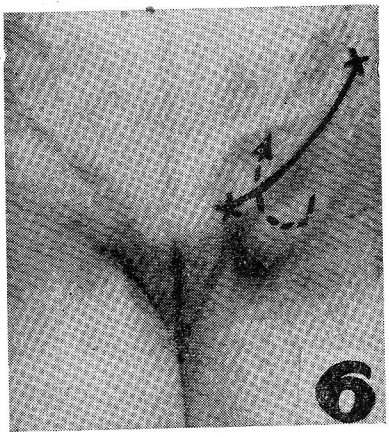
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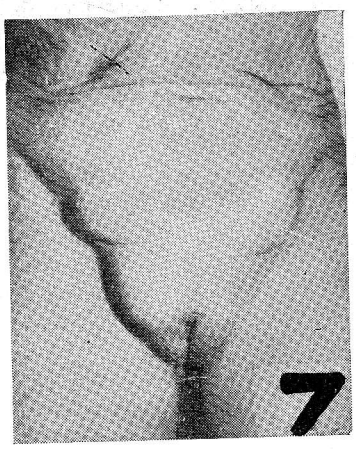
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served that whenever there is intestinal quiescence, the chest and the abdomen act as a single unit. All the respiratory signs on palpation and auscultation (viz. TVF, breath sounds and VR) of the chest can be perceived in a similar way all over the abdomen including the entire anterior abdominal wall, the sides of the abdomen and all over the back including the renal angles, and areas just above the iliac crests and the sacrum. In one case of perforative peritonities in an old man, the vocal resonance could be heard on auscultation just above the greater trochanter of the femur.

It can be further emphasized here that it is not the absence of peristalic sounds that strikes one first on auscultation of the abdomen but the active presence of the patient's groan heard all over that appears ominous in cases of acute abdomen. In normal people, such a transmission of chest sounds on to the abdominal parietes is restricted to the uppermost part of the anterior abdominal wall, i.e. the epigastrium.

The mechanism of this interesting phenomenon described above is difficult to explain. It is possible that normally the sound waves due to gastro-intestinal peristalsis actively repel most of the respiratory sounds so that very little is transmitted to the abdominal parietes via the abdominal cavity or the walls of the abdomen. Further investigations with the aid of a phonograph to elicit and compare phonothoraco- and phonoabdomino-grams for the better understanding of this phenomenon are pending till better facilities.

(IV) A Palpation Finding in Distended Urinary Bladder :

It is a common experience that neither the clinical teachers nor the books on Clinical Surgery mention that a distended urinary bladder, if not very tense, gives positive fluctuation as any other intra-abdominal cystic swelling. I feel this finding forms a good aid in the differential diagnosis of swellings in and around the hypogastric region.

ACKNOWLEDGMENTS

I am thankful to Dr. K. Das, F.R.C.S. (Eng. & Edin), Calcutta for his kind permission to use Figs. 2, 3, 4, 5 and 6 from his "Clinical Methods in Surgery" and Dr. G. D. Adhia, F.R.C.S. (Eng.), Bombay for Fig. 7. A part of the method for the hip joint is taken from Bailey's "Physical Signs in Surgery", H.K. Lewis & Sons, London (1960).

LEGENDS

Fig. 2: Inguino-scrotal curve, normal on (R) side and convex on the (L) side due to an inguino-scrotal swelling.
Figs. 3 and 4: Purely inguinal or scrotal swelling does not alter the curve.
Figs. 5 and 6: A line traced along the outer margin of the femoral hernia has no continuity with the inguino-scrotal or the inguino-labial curve. The line instead forms an acute angle with either curve.
Fig. 7: Inguinal hernia in a female. Compare it with Fig. 6.

THE USE OF A SILICONE RUBBER SPLINT FOR POST-VASECTOMY VAS DEFERENS ANASTOMOSIS: REPORT OF A NEW OPERATIVE TECHNIQUE*

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ABSTRACT

A new technique for the anastomosis of the vas deferens after vasectomy is described; an important feature is the use of a large diameter splint of silicone rubber. The splint is placed intraluminally in such a way as to reduce tension on the anastomosis during the crucial immediate post-operative period. Of the 10 operations performed with this technique, successful recanalization was achieved in 9 and pregnancy was recorded in 3 during a one to fourteen month follow-up period. It is felt that the modifications of the operative technique described here may lead to further improvement of the results in vas deferens anastomosis after vasectomy.

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INTRODUCTION

Vasectomy is becoming an important method for population control in many countries. The simplicity of the operative procedure and its reliability, with very small failure rate, little or no loss of man-hours and the relative freedom from complications makes it a method acceptable to many men. However, its one disadvantage has been that the operation has become reputed as one that is difficult to reverse. The popularity and acceptability of the operation can be further enhanced if it is shown that fertility can be restored whenever desired or indicated by a reversal procedure of vas recanalization.

Satisfactory results of vas deferens anastomosis have been reported recently, specifically with one of the commonly used techniques of this operation (1, 2). However, in our experience with this operation, we felt that it might be possible to further improve upon these results if certain modifications were made in the existing operative technique.

A new operative technique for vas deferens anastomosis is described in which the splint material, the splint size and the splint placement have been modified with the anticipation of achieving better results. This communication is the report of our first 10 cases utilizing this modified technique for vas recanalization.

MATERIAL AND METHODS

The recanalization procedure described below was performed in a group of ten men with previous surgical vasectomies. Only those cases where the previous vasectomy had been carried out very low in the scrotum involving the convoluted portion of the vas deferens near the cauda epididymis, were excluded from the present series. The exclusion of these cases was based on the fact that it is not possible to introduce a splint inside the lumen of the convoluted portion of the vas deferens.

There were five cases each in the age groups of 21 to 30 years and 31 to 40 years. Among the ten vasectomized patients, one was a bachelor who now desired to get married. Of the remaining 9, 5 had lost children following vasectomy and 4 desired to have more children. The duration between vasectomy and the vas deferens anastomosis operation varied between 3 months and 3 years (Table I).

TABLE I

Duration between vasectomy and vas anastomosis operation.

DURATION BEFORE ANASTOMOSIS	NO. OF CASES
3 months	1
9 months	1
1-2 years	6
2-3 years	2

OPERATIVE TECHNIQUE

The operation was carried out under general anesthesia. Each side of the scrotum was explored by an anterior vertical incision. The two segments of the severed vas deferens and the intervening fibrous nodule were defined with minimum disturbance to the vascularity of the two segments. The fibrous nodule and the adjoining fibrosed portions of the vas deferens were excised with a sharp knife (Figure 2:i) and the patency of the two segments of the vas deferens was determined by introducing a nylon thread 0.01 inches in diameter into the lumen of each segment and by injecting saline into the distal segment. The whitish fluid extruding from the proximal segment was collected and examined.

The splint consists of medical grade silicone rubber tubing (Silastic^{R}*-Dow Corning) with straight, round bodied needles attached to both ends (Figure 1). The needles were purchased separately and attached to the tubing with the use of Silastic Medical Adhesive Type-A (Dow Corning). The largest diameter tubing which could be introduced into the lumen of the vas deferens without causing damage to its epithelial and muscular layers was selected for the splintage. It was found that in the majority of the cases, the lumen of a normal vas deferens easily admitted a Silastic tubing with an outer diameter of 0.037 inches. In cases where the vas lumen was found to be smaller, a Silastic tubing with an outer diameter of 0.025 inches was used.

*Polydimethylsiloxane

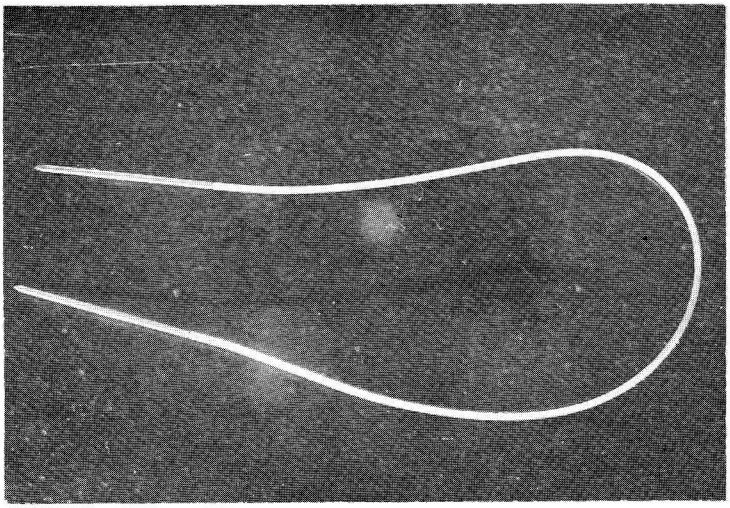

Figure 1. The splint consists of Silastic tubing with round bodied needles attached to both ends.

The needle carrying the splint was introduced inside the lumen of first the proximal and then the distal segments of the vas deferens and was brought out by piercing the wall of the vas deferens at a distance of about 1.5 to 2.0 cm from each cut end (Figure 2:ii). The two ends of the vas deferens were anastomosed over the splint with 4 interrupted sutures of 6/0 arterial silk on an atraumatic needle. When placing the sutures, care was taken to include only the muscular and the adventitial layers of the vas deferens without entering its lumen. The anastomosis was further reinforced with the approximation of the fasciae around the two segments of the vas deferens. The free ends of the Silastic splint were brought out through the scrotal skin and were tied together (Figure 2:ii and iii). The scrotal incision was closed in layers. Gentle handling of the tissues, avoiding the use of crushing instruments and proper hemostasis were considered very important features of the surgical technique.

The patients were kept in bed for 7 days to further insure against the development of tension on the anastomosis which is very likely to occur if the patient is mobilized early. Firm tissue union occurred by the 7th post-operative day when the splint was removed. The splint was removed without any anesthesia by cutting one exterior limb of the splint with a pair of scissors and pulling on the other limb of the splint. For removing the splint, the same surgical precautions are taken as are taken for removing an ordinary skin stitch. The removal of the splint wasy very easy and there was no incidence of bleeding or any other complication during its removal.

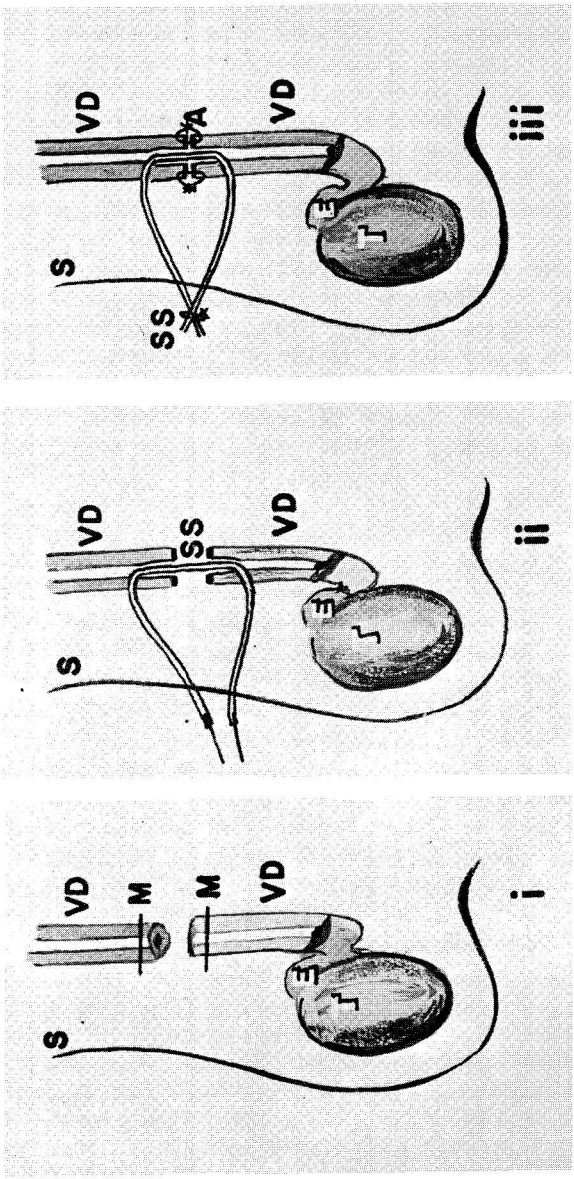

Figure 2. Operative technique for vas deferens anastomosis using a silicone rubber splint.
S -- Scrotum; VD -- vas deferens; T -- testis; E -- epididymis;
M -- site of vas section; SS -- Silastic splint; A -- anastomosis.

RESULTS

In the present series, the gap between the two segments of the vas deferens after excision of the intervening fibrous nodule varied between 1.5 cm and 4.0 cm with an average of 2.5 cm.

The ten operated cases were followed-up for periods ranging between one month and fourteen months. Successful recanalization was achieved in 9. In the 8 cases where the follow-up was more than 4 months, the sperm count ranged between 20 million per ml and 154 million per ml with sperm motility ranging between 40 percent and 80 percent one hour after the collection of the semen. Pregnancy was recorded in 3 cases. In one case where the follow-up was for one month only, the sperm count was 2 million per ml with sperm motility of 40 percent. One case continued to show absence of spermatozoa in the semen even at the end of one year and was considered a failure of the recanalization procedure. In all the successful cases, the number, morphology and motility of the spermatozoa showed improvement with the passage of time.

DISCUSSION

Many methods for vas recanalization after vasectomy have been described. Between the 'non-splint' and the 'splint' techniques, the latter appears to be more favored. A variety of splints have been used in the past, including catgut (3), silkworm gut (4), stainless steel tube (5), tantalum and stainless steel wire (6, 7) and polyethylene tubing (8). Perhaps the most commonly used splint today is the one made from nylon. The basic technique for vas deferens anastomosis using a small monofilament nylon thread splint has been adequately described (9) (Figure 3).

In our experience with vas recanalization, we found that the use of the nylon splint in the manner described above has the following disadvantages:

(a) Nylon, like the other materials which have been used so far, causes a certain degree of local tissue reaction. The inflammatory reaction so produced may lead to fibrosis and stricture formation at the site of the anastomosis. A material which is less reactive and more acceptable to the tissues is therefore likely to give better results. In the present study, the Silastic splint was preferred since it has been shown that this material causes little or no tissue reaction. Silastic, in various forms, has already been extensively and satisfactorily used for subdermal and deeper implantations (10, 11).

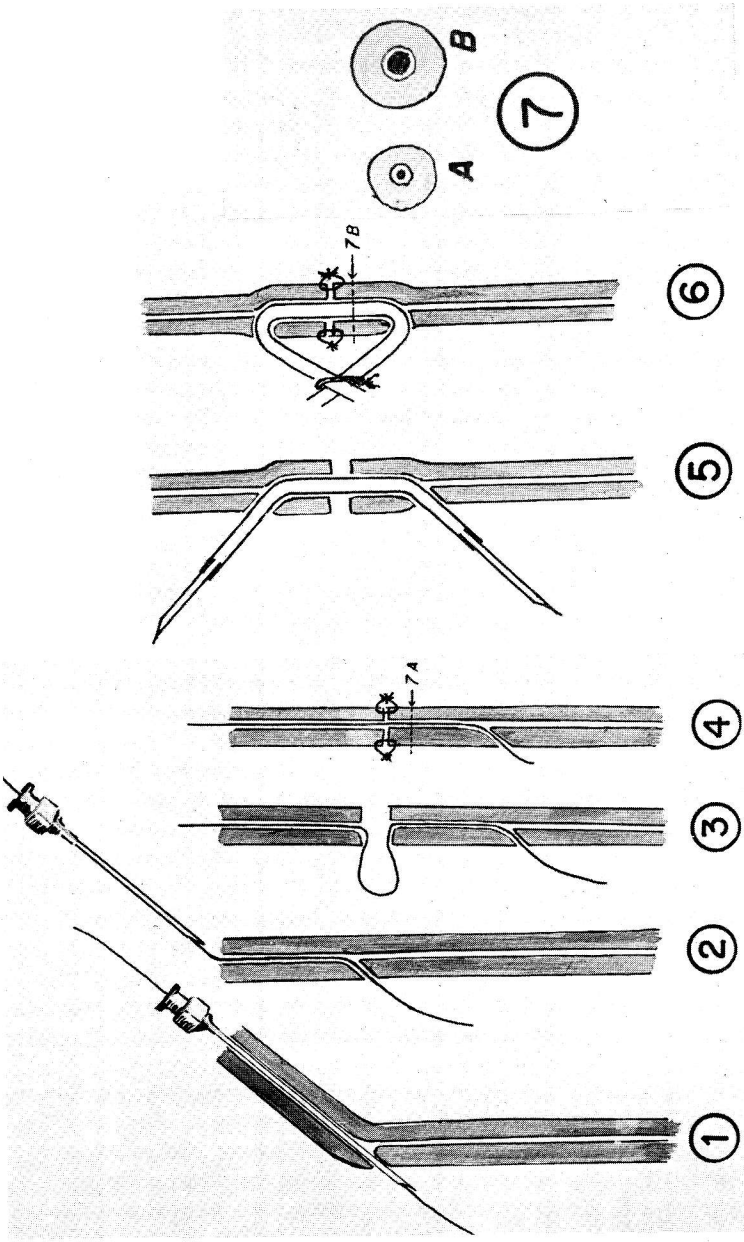

Figure 3. (1) (4) show the method of nylon thread placement by the hypodermic needle technique. (5) and (6) show the method of placement of the Silastic splint of a larger diameter, and the expansion of the vas lumen caused by the splint. (7) shows the cross-sectional appearance of the vas deferens bearing a small diameter nylon thread(A) and the large diameter Silastic splint (B).

(b) The size of the nylon thread which can be introduced into the lumen of the vas deferens by the hypodermic needle technique is usually small. While such a small diameter splint may succeed in bringing about proper alignment of the two segments of the vas deferens (Figure 3: (4)), it does not open up the two anastomosing segments. Normal vas deferens with its highly muscular wall and the mucosa thrown into folds, does not have the appearance of a hollow tubular structure like the intestine or the ureter. It was therefore felt that a device that could cause expansion of the vas lumen and present two expanded ends for the anastomosis, would give better results by preventing luminal narrowing and stricture formation during the process of healing. A large diameter splint was therefore preferred. The 0.037 inch outer diameter Silastic tubing which has been used in the present technique is about three-and-one-half times as thick as the 0.01 inch monofilament nylon thread and causes a greater expansion of the vas lumen (Figure 3: (5) - (7)). However, to introduce a soft material like Silastic intraluminally, it was necessary to devise a new type of splint by attaching straight, round bodied needles on both ends. This greatly facilitated the introduction of the splint in the manner described (Figure 2:ii, 3: (5) and (6)).

(c) The final placement of the nylon splint, as described in the usual technique (Figure 3: (4)) was considered to be unsatisfactory. This observation was based on the fact that tension usually develops on the suture line after the vas deferens anastomosis. The occurrence of tension is the result of excision of a segment of the vas deferens at the time of vasectomy. The gap between the two segments of the vas deferens ready for anastomosis may vary from 1.0 cm to 5.0 cm or more, depending upon the extent of the previous excision. The downward pull of the testis further aggravates the already existing tension on the anastomosis (Figure 4:i). The method of splintage with the nylon thread as described above does not prevent or reduce the tension on the suture line (Figure 4:ii). In the present technique of splint placement, the two ends of the Silastic tubing are exteriorized and tied together (Figure 4:iii). This helps to keep the two anastomosing segments of the vas deferens in apposition in spite of the moderate degree of tension which develops. Also, the actual technique of the anastomosis and the introduction of the sutures is greatly facilitated due to the close approximation of the two ends of the vas deferens which is seen to occur when the splint is placed as described above.

Table II shows some of the results achieved by other workers (1, 2, 12 14). It is obvious that good results can be achieved with different operative techniques for vas deferens anastomosis. The aim of this presentation is not to make statistical comparisons with any of the larger series shown in Table II, but to report our initial experience with a new operative

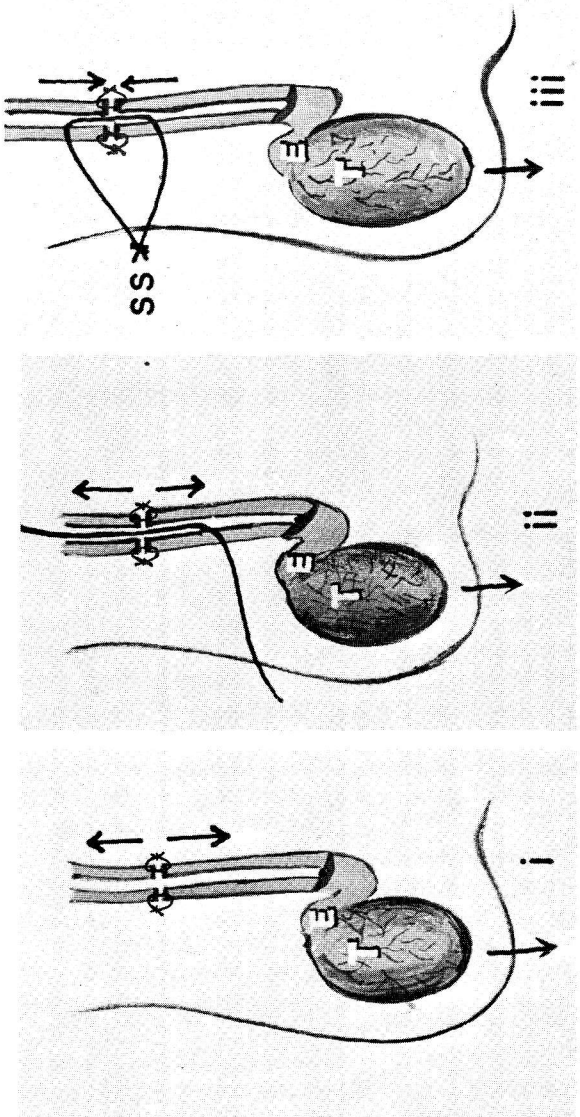

Figure 4. (i) shows the anastomosis of the vas deferens without the use of a splint. The tension on the suture line is aggravated by the downward pull of the testis. (ii) shows the method of placement of the nylon thread splint. NS -- nylon splint. (iii) shows the method of Silastic splint (SS) placement with close approximation of the vas segments and reduction of tension on the suture line.

technique and to emphasize in particular some of its underlying principles. It is felt that the modifications enumerated in the present technique are likely to lead to further improvement of the results for vas anastomosis procedures. More recent experience of the authors has shown that the present operative technique may become extremely useful particularly in those cases where a long segment of the vas has been excised at the time of previous vasectomy. In these cases, because of the presence of excessive tension on the suture line, it is often necessary to ensure firmer healing of the anastomosis before the splint is withdrawn. This may require retention of the splint across the anastomosis for a period longer than one week. The use of a splint made from Silastic under these circumstances would have a distinct advantage since it may be kept as a splint for a longer duration without the fear of causing excessive tissue reaction, fibrosis or stricture formation.

TABLE II

Results of vas anastomosis achieved by various intestigators.

INVESTIGATOR	SUCCESS RATE*
O'Conor, V.J. (12)	35 - 40%
Jhaver, P.S. (13)	80%
Phadke, G.M., Phadke, A.G. (1)	86% (63 out of 73)
Kar, J.K. (2)	70% (63 out of 90)
Mehta, K.C., Ramani, P.S. (14)	87% (15 out of 17)

*Post-operative reappearance of spermatozoa in the semen.

ACKNOWLEDGEMENTS

The authors wish to thank Mr. Michael S. Newash of Dow Corning Center for technical advice in preparing the Silastic splint.

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METRONIDAZOLE IN DRACUNCULOSIS

A Preliminary Report of a Therapeutic Trial

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Metronidazole in Dracunculosis

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Dracunculosis, ascariasis and filarasis are the most important diseases caused by nematodes which affect a large number of persons in the tropics every year. While therapeutic and prevenitve aspects of ascariasis and filariasis have received considerable attention, guinea-worm disease has been neglected by the clinician and by other medical scientists. The apathy of the patient infested by the guinea-worm is understandable, since till recently, the age-old method of extracting the worm by rolling it on a stick was all that was offered to him by way of treatment. This method has been found to be unsatisfactory, unreliable and often hazardous since rupture of the worm leads invariably to aggravation of the lesion and worsening of the symptoms.

Recently, there have appeared reports of trials of certain chemotherapeutic agents for dracunculosis. Notable among these is the reported effectiveness of niridazole (ambilhar—Ciba) in the treatment of this disease (Gilbert, 1965; Oduntan *et al.* 1967; Kothari *et al.*, 1968a, 1968b, in press).

In our study of this disease in the Department of Surgery, K.E.M. Hospital, Bombay, various chemotherapeutic agents were tried and among these

metronidazole (flagyl—May & Baker) was found to be both effective and safe in controlling the acute clinical manifestations of the disease. The results of treatment with metronidazole in 12 cases of dracunculosis forms the subject of this preliminary communication.

Material and Method

All the 12 cases who presented for this trial had acute lesions of durations varying from 4 days to 30 days. 3 cases had multiple lesions. All the patients in this series gave the history of residence in endemic areas and the diagnosis in all cases was established from recent history of extrusion of part of the worm or from clinical examination showing the worm in the lesion. All the patients in this series were adult males.

Metronidazole was administered orally at the rate of 25 mg. per kg. body weight per day in divided doses for 10 days. In one case the drug was administered for 15 days.

Since this was only a pilot study, the response to therapy was recorded as: (1) Satisfactory—when the lesion showed healing and the patient felt subjective improvement during or soon after completion of the treatment. (2) No response—When there was no subjective improvement and the lesion remained unaltered or became worse. It has been our observation during the clinical study of this disease that without treatment the acute guinea-worm lesions may persist for periods ranging between 6 weeks and 6 months (Kothari *et al.*, 1968a) during which the patient is partially or completely disabled. The experience of the patients who had suffered from this disease in the past and the past clinical and therapeutic observations of the clinicians were taken into account in recording the response of the disease in the present study.

Results

All the cases in this study showed considerable improvement in their symptoms and clinical signs.

In 9 cases the lesion showed healing during the 10-day period of treatment and in the remaining 3 cases healing was seen 5 to 7 days after the completion of treatment. Clinical examination showed that all the acute lesions had become quiescent.

There was improvement in cellulitis and other local signs of inflammation including oedema. The patients at the same time felt remarkable relief from pain allowing early mobilisation. In 4 cases a whole worm was extruded through the lesions. In another 4 cases the worms ruptured while the patient tried to pull it out leaving a part of the worm inside the tissues. In the remaining 4 cases the worms failed to come out through the lesions. Although the lesions healed rapidly in cases where the whole worm was extruded causting the patient considerable and immediate relief, it was observed that under this treatment the lesions in which whole or a part of the worm was retained healed equally well. However, in the follow-up study it was observed that in cases where the whole of a part of the worm was retained in the tissues, the patient continued to get slight itching locally for 4-6 weeks after the lesion had healed. A longer follow-up is needed to study the fate of these retained worms after treatment with metronidazole. No new lesions appeared during or soon after completion of the treatment with metronidazole. There were no side effects following administration of metronidazole in the dosage mentioned above.

Conclusion

Till recently there had been no specific treatment for dracunculosis. Relief from the disease was obtained mainly by mechanically pulling out the worm through the lesion which took days and sometimes weeks, subjecting the patient in the meantime to pain, immobilisation and often to aggravation of the lesion. The discovery of the effectiveness of niridazole against this disease prompted us to carry out a pilot study with metronidazole, another member of the nitroimidazole group of drugs.

From the present study it was found that metronidazole was effective in the treatment of acute lesions of dracunculosis. However, it is necessary to carry out a controlled study in large number of cases to adequately evaluate the effect of metronidazole in this disease.

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Management of Dracontiasis

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In the management of dracontiasis, many remedies, including surgical measures, have been tried in the past. Recently, we were presented with the opportunity to use a new chemotherapeutic agent, in a large field trial, for the management of active guinea-worm disease. A variety of guinea-worm lesions were seen and several different aspects of the disease were studied (Kothari *et al* 1969a, 1969b, 1970a, 1970b, 1970c). The advent of this new drug (niridazole) has, in our experience, radically changed the management of dracontiasis. This has encouraged us to review briefly the measures used so far, as well as to present a definite plan for the management of dracontiasis.

Moses was perhaps the first in history (Boyd 1961; Markell 1968; Kintzen 1968) to demonstrate the classical method of removing the guinea-worm when he made a serpent of brass and put it on a pole, thus providing a visual aid to instruct his people in the technique of removing the parasite. The motifs of caduceus and Aesculapius (Fig. 1) probably owe their origin to this event. A saying quoted by Moorthy (1932b) 'EK NARU HAZAR DARU' sums up the problem faced by a clinician in the management of dracontiasis. In the absence of a specific wormicidal drug, the management has consisted of every possible naustrum (Table I) and or surgical intervention. Parekh and Kulkarni (1958) in a controlled trial evaluated the efficacy of many of these measures, only to conclude that none had any specific action against guinea-worm disease.

TABLE I

"Ek Naru, Hazar Daru"

1.	Moses and his Magic Wand
2.	Fresh Aerial Root of Banyan Tree
3.	Bug between Two Pieces of Bread
4.	Central Eye of Peacock Feather
5.	Various Leaves as Local Dressings
6.	D.C.N. (Grass + NH_4Cl. + IODINE)
7.	Guinoid
8.	Calmist (Camphor + Asfoetida + Lime)
9.	Diethylcarbamazine
10.	Phenothiazine Orally or Locally
11.	Surgical Extraction
12.	Niridazole (Ambilhar — CIBA)

The management of dracontiasis may be considered according to the stages in the development of the disease:

1. Prodromal symptoms
2. Subcutaneous symptomless worm
3. Active guinea-worm lesion
4. Secondary bacterial infection
5. Sequelae

PRODROMAL SYMPTOMS

These occur in about half the number of patients, are short-lived and generally do not require any treatment. The treatment in severe cases is symptomatic with antipyretics, analgesics and antihistami-

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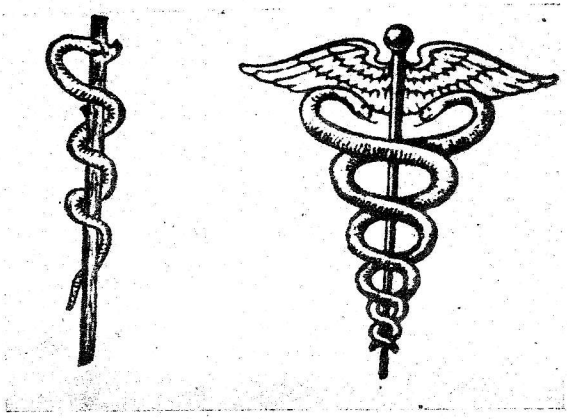

FIG: 1. The motifs of caduceus and Aesculapius.

nics. In the event of an anaphylactic reaction, subcutaneous injection of adrenaline 1:1000 gives immediate relief (Moorthy 1932a; Belding 1966; Manson-Bahr 1966).

ACTIVE GUINEA-WORM LESION

(a) *Local Dressing:* A clean dry dressing is all that is needed in the majority of open guinea-worm lesions. A large absorbent dressing may be applied when multiple guinea-worm ulcers exude a large quantity of discharge or when a guinea-worm abscess has burst open. In the rural area, majority of the patients use a variety of leaves for local dressing. This is because of the belief in the curative value of certain leaves as also due to the scant medical facilities in the remote areas where the disease generally occurs. In our experience, treating such patients with niridazole, without any surgical dressing, did not delay healing of the lesions (Kothari *et al* 1968a; 1969a).

(b) *Specific Therapy with Niridazole:* Niridazole (Ambilhar-CIBA) is a nitrothiazole and was first introduced as a schistosomicidal agent (Jordan, 1966). Raffier (1965), Oduntan *et al* (1967) and Kothari *et al* (1968a; 1968b; 1969a) found it to be highly effective in guinea-worm disease. We have carried out an exten-

TABLE II

Healing of the lesions according to their severity

	Type of lesions	Niridazole			Placebo		
		Total No. of patients	Healed	Unchanged or worsened	Total No. of patients	Healed	Unchanged or worsened
X^2 — 16.497 df — 1 P .001	Severe	41	37 (90%)	4 (10%)	32	15 (47%)	17 (53%)
X^2 — 12.224 df. — 1 P .001	Moderate	12	12 (100%)	0	20	6 (30%)	14 (70%)
Number too small for analysis.	Mild	3	2 (66.6%)	1 (33.3%)	10	7 (70%)	3 (30%)

sive study of niridazole in dracontiasis in several villages of the Kolaba district in the State of Maharashtra. In a pilot study of 46 cases, the cure rate was more than ninety per cent (Kothari *et al*, 1968a). Later, a blind, controlled trial (Kothari *et al*, 1969a) using a placebo as a control, was carried out on a series of 118 patients which closely confirmed the results of the pilot trial (Table II).

The therapeutic action of the drug starts within 48 to 72 hours of the initiation of the treatment and is seen as a marked amelioration of the local symptoms. The local signs show regression by about the 5th day and in the majority of patients the lesions heal within 15 days of starting the treatment. We feel that the drug irritates the worm initially, thereby promoting quicker spontaneous expulsion; later, it paralyses the worm, thus rendering its manual extraction easier. In one third of the patients treated with niridazole, the worm is probably killed *in situ* and is therefore not expelled. The rate of healing however, is not affected by the expulsion or retention of the worm (Kothari *et al*, 1968a, 1969a). Rarely, as observed in two of our patients, under niridazole therapy, the worm escapes through the rectum, a fact already reported by Raffier (1965). The symptomatic relief noticed as early as the third day of the treatment is probably due to the paralysing effect of the drug on the worm which can no longer irritate the tissues. It is difficult to say whether the drug also has a non-specific anti-inflammatory action. In summary, it can be stated that niridazole greatly facilitates the management of a very disabling parasitic disease for which no satisfactory treatment was available so far. When niridazole is used, surgical intervention is rarely called for and antibiotics can be spared. The dosage of niridazole used in this series was 25 mg./kg. body weight (one tablet of 500 mg. three times a day for an average adult), given daily for 10 days. All patients were advised to take the drug after food to minimise gastric irritation.

The drug gives rise to intense red colouration of urine which may be mistaken for haematuria. The patient must be foretold of this otherwise innocuous side effect. In many patients the drug gives rise to headache, bodyache and gastric discomfort. Repeated assurance by the physician is necessary for the patient to continue taking the drug. The side effects in our trials were never so severe as to force withdrawal of the drug. In two patients, inadvertent overdosage produced neuropsychiatric reactions on the third day of the treatment. These were manifested as restlessness and delirium, and in one case as involuntary unilateral movements of the face and limbs. These side effects disappeared rapidly after withdrawal of niridazole.

SECONDARY BACTERIAL INFECTION

The majority of guinea-worm lesions are open and are secondarily infected or rather colonised by bacteria, the commonest organism being Staph. aureus coagulase positive (Kothari *et al*, 1969b, 1970c). In our experience, both closed (sterile) and open (infected) guinea-worm lesions respond equally well to niridazole therapy without the additional use of any antibiotics (Kothari *et al*, 1968b, 1969a, 1969b, 1970c). Bandi (1968) has used streptomycin for instillation into closed guinea-worm abscess cavities after aspiration and has found this measure to be useful. In our *in vitro* study, streptomycin was found to

be effective against most of the organisms isolated from open guinea-worm lesions (Kothari *et al*, 1970c).

ROLE OF SURGERY

Many people (Manson-Bahr and Walter 1962; Belding 1965; Manson-Bahr 1966; Kintzen 1968; Markell 1968) recommend the use of a matchstick around which the emerging worm can be progressively wound, after douching the lesion repeatedly with water. This method, despite many claims, is not always successful and it takes a long time before the worm comes out completely (Manson-Bahr 1966; Belding 1965). During this process, the worm often breaks leading to severe local and general reactions. Surgical attempts at removal of the worm are still made on a wide scale wherever the facilities exist in the endemic areas (Banks, 1968). Books on parasitology often depict that the removal of the worm through a surgical incision is quite easy (Fig. 2) and therefore applicable to a large number of cases. We have, however, found that the worm lies very tortuously, over wide areas, in different tissue planes at the same time (Fig. 3) and, in practice, it is very difficult to take out the worm intact. It was rightly pointed out by Elliott (1942) that the attempt at surgical removal of the worm is like trying to find a needle in a haystack. The worm as it lies in a zig-zag manner compels the surgeon to make multiple incisions with quite an uncertainty about removing the worm intact or completely (Belding 1965).

An acute guinea-worm abscess calls for incision, evacuation and primary closure of the abscess, under niridazole cover. As described elsewhere (Kothari *et al*, 1970b) the worm sometimes lies free in a closed subcutaneous guinea-worm abscess. This fact is exploited by the rural "naru specialists" or "tumdi-walas" who apply powerful suction through a hollow tube and sometimes succeed in removing a part or the whole of the worm. This method is unpredictable and the authors have suceeded in

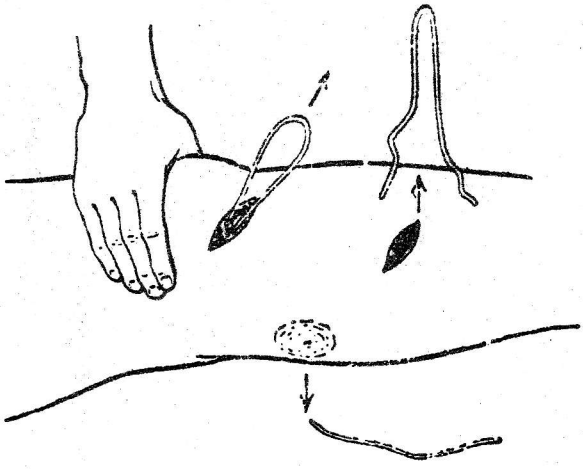

FIG: 2. Removal of the worm through a surgical incision. (From Manson's Tropical Diseases, 1963, after N. H. Fairley).

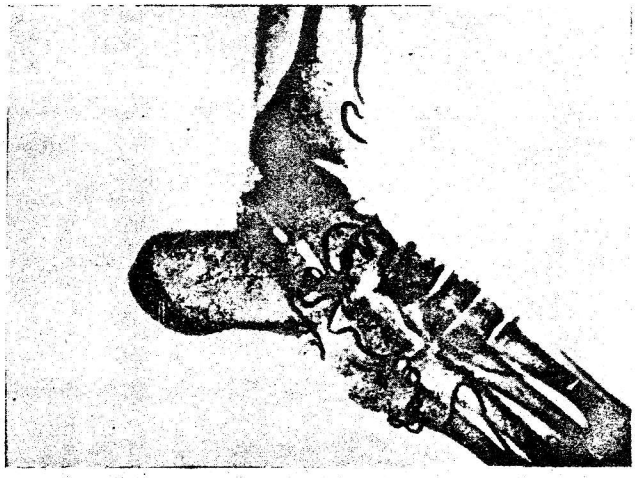

FIG: 3. The worm lying very tortuously, over wide areas, in different planes at the same time. (From Manson's Tropical Diseases, 1963, after Dr. Botreau-Roussel).

removing the worm intact through aspiration, only on two occasions. The afflicted villagers do not testify to the claims of the "tumdiwalas".

Reddy *et al* (1968), have reported acute guinea-worm arthritis of the knee joint treated by arthrotomy and removal of the intra-articular worm. Acute guinea-worm arthritis is characterised by intense fibrinous exudate in the joint. In our experience, this complication of guinea-worm disease calls for aspiration of the joint, compression bandage, and physiotherapy, and with the availability of niridazole no surgical intervention is required (Kothari *et al*, 1968b).

SEQUELAE OF GUINEA-WORM DISEASE

The sequelae of guinea-worm lesions consist of cysts containing calcified guinea-worm, tendon contractures and ankylosis of joints (Kothari 1965; Kothari *et al*, 1970a; Kothari *et al*, 1970b). The cysts if troublesome may be excised and the ankylosis and contractures should be surgically corrected to restore function.

PROPHYLAXIS

It is indeed a pity that the disease, which is completely preventable, should still be so widespread. The preventive steps should be closure of infected well and ponds, and supplying filtered water to all areas wherever the disease is endemic. In the absence of such a water supply, the residents in endemic areas must be educated and informed about the efficacy of filtering their drinking water through ordinary cloth. An infected cyclop measures at least 1.5 x 1 mm. and can be arrested by an ordinary cloth filter. Other methods which have been used to get rid of the cyclops infected with larvae are: boiling the water, using potassium permanganate or D.D.T. and breeding fishes of the genus Barbus in infected ponds (Belding 1965). All the step wells must be replaced by parapated wells and the drinking water must be protected from pollution by guinea-worm patients. There are some reports that the use of diethylcarbamazine following

exposure to infected water may abort the guinea-worm disease by preventing maturation of larvae into adult female worms (Onabamiro, 1956). There are no further reports confirming this observation.

SUMMARY AND CONCLUSIONS

General management of guinea-worm disease is described. It has been emphasised that niridazole is specific for all active lesions and promotes rapid healing of even infected lesions without the concomitant use of antibiotics. Surgery is called for in certain acute conditions and for sequelae of guinea-worm disease.

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NIRIDAZOLE IN DRACONTIASIS: A CONTROLLED STUDY

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Niridazole (Ambilhar—CIBA) has been reported to be useful for dracontiasis (RAFFIER, 1965; ODUNTAL et al., 1967; KOTHARI et al., 1968). Studies by Raffier and Kothari were not controlled whereas Oduntal et al. had kept some patients as untreated controls. Having had some initial experience of Ambilhar in guinea-worm disease, we decided to undertake a double-blind study of it.

Material and methods

We carried out a field study in 3 villages of the Kolaba district near Bombay. 150 subjects in whom a definite diagnosis of guinea-worm disease was made were selected and their lesions were graded as severe, moderate or mild. As reported previously by KOTHARI et al. (1968), the lesions were graded as (i) *severe:* when there was acute oedema, erythema, ulcer and swelling accompanied by severe pain and marked disability; (ii) *moderate:* when there was local swelling and ulcer with some pain and disability; (iii) *mild:* when there was local swelling and ulcer or both but no disability. Initial examination was carried out by two investigators who kept a full record of each patient's lesions. The same investigators examined the patients during subsequent follow-up. After the initial examination, the patient was referred to a third investigator who prescribed either niridazole or placebo according to a previously randomized list of 75 patients for each treatment. In view of certain specific side-effects produced by niridazole e.g. red discoloration of urine, only the third investigator recorded the side-effects, the other two investigators confined themselves to the clinical examination of the patient, and were therefore not aware of the nature of the treatment prescribed. Niridazole was given at a dose of 25 mg. per kg. body weight (1 tablet of 500 mg. t.d.s. for an average adult) daily for 10 days. Placebo tablets were similarly administered. No other local or systemic treatment was prescribed. The patients were followed up regularly for up to 60 days when the final assessment of their local lesion and general condition was made. Of the 150 selected for the study, 9 in the niridazole group and 13 in the placebo group could not be followed up because they had left the area. 10 in the niridazole group stopped the drug after taking it for a day or two and were not included in the analysis. The details of the remaining 118 patients, who were regularly followed up, are discussed here.

We are grateful to the Dean, K.E.M. Hospital, Bombay, for allowing us to carry out this study, to Drs. B. M. Dhatrak and S. N. Bhave for their unending assistance, and to CIBA of India Limited, Bombay, for supplying us niridazole (Ambilhar).

Of the 118 patients (59 males and 59 females) 29 males and 27 females received niridazole; 30 males and 32 females received the placebo. Patients were aged 4-60 years, 71 were aged 11-30 years, 34 being in the niridazole group and 37 in the placebo group.

Table I gives details.

TABLE I. Details of patients

	Niridazole group	Placebo group
Age 11-30	34	37
Past history of guinea-worm	36	38
No past history of guinea-worm	20	24
Duration of present illness		
1-3 weeks	18	26
4-8 „	33	30
8- „	5	6
Lesions		
severe	66	39
moderate	39	50
mild	13	20
total	118	109
Patients with		
1 lesion	26	32
2 „	14	18
3 „	7	8
4 „	6	3
5-8 „	3	1

In addition to a complete clinical examination, each patient was asked about his prodromal symptoms, and swabs for bacterial culture were taken from open lesions. Details of all these will be reported separately.

Results

The niridazole and the placebo groups were statistically homogeneous in age and sex distribution, presence or absence of guinea-worm infection in the past, duration of present illness and the number of lesions in each patient. However, when the group of patients with severe lesions (niridazole 41, placebo 32) was compared with the group having moderate and mild lesions (niridazole 15, placebo 20), it was found that a significantly higher proportion of patients with severe lesions received niridazole treatment ($\chi^2 = 4{\cdot}94$, $P < 0{\cdot}05$).

Healing of lesions

Details of healing are shown in Tables II, III and IV.

In the niridazole group healing occurred rapidly whenever there were only 1-3 lesions; when there were more, healing took 3-4 weeks. In the placebo group healing took more than 4 weeks in the large majority of patients, irrespective of the number of lesions.

To determine the relationship of healing of the lesion according to its severity, patients with mild and moderate lesions were grouped together as the number of patients with mild lesions was rather small. Results are shown in Table IV. An analysis of the data showed that the triple interaction (treatment × severity × results) was not significant ($\chi^2 = 0{\cdot}196$, $P < 0{\cdot}50$). This implies that the response to the drug was not significantly different from response to the placebo in patients with severe lesions, compared with that in patients with moderate or mild lesions. This incidentally reduces the relevance of unequal distribution of severe lesions between the niridazole and the placebo groups of patients.

TABLE II. Healing of the lesions in groups treated with niridazole or placebo

Drug	Total no. of patients	Healed	Unchanged or worsened
Niridazole	56	51 (91%)	5 (9%)
Placebo	62	28 (45%)	34 (55%)

$\chi^2 = 27{\cdot}993$ df = 1 $P < 0{\cdot}001$

TABLE III. Healing of lesions (No. of days after starting treatment)

	0-10 days	11-20 days	21-60 days	Total
Niridazole	27 (53%)	20 (39%)	4 (8%)	51
Placebo	1 (3%)	2 (8%)	25 (89%)	28

$\chi^2 = 51{\cdot}594$ df = 2 $P < 0{\cdot}001$

TABLE IV. Healing of the lesions according to their severity

	Type of lesions	Niridazole			Placebo		
		Total No. of patients	Healed	Unchanged or worsened	Total No. of patients	Healed	Unchanged or worsened
$\chi^2 = 16{\cdot}497$ df = 1 $P < 0{\cdot}001$	Severe	41	37 (90%)	4 (10%)	32	15 (47%)	17 (53%)
$\chi^2 = 12{\cdot}224$ df = 1 $P < 0{\cdot}001$	Moderate	12 } 15	12 } 14 (93%)	0 } 1 (7%)	20 } 30	6 (30%) } 13 (43%)	14 (70%) } 17 (57%)
Number too small for analysis	Mild	3	2	1	10	7 (70%)	3 (30%)

Extrusion of worms

In the niridazole group the worms were spontaneously extruded in 30 (59%) of the 51 completely healed patients. In 22 the worm was extruded within 5 days and in the remaining within 6-14 days of starting the treatment. The rate of healing was unaffected

by the extrusion or retention of the worm. In the placebo group the worm was spontanenously extruded in only 3 (11%) of the 28 patients who healed completely.

Side effects

21 of the 56 patients in the niridazole group had 1 or more of the following side effects: 13 vomiting, 9 giddiness, 3 headache, 3 abdominal pain, 2 diarrhoea, 2 anorexia, 1 fever, 1 weakness and 1 had generalized itching. The side effects were generally mild and patients continued to take the drug, although persuasion and reassurance were sometimes required. 6 patients who received placebo treatment also complained of giddiness, vomiting, diarrhoea and red coloration of urine.

Discussion

Dracontiasis can be eradicated by supplying filtered drinking water in endemic areas. Such a simple necessity, however, has not been provided for in many parts of India and hence the incidence of the disease in this country is still very high—in 1957 there were approximately 5 million cases in India (JASWANT SINGH and RAGHAVAN, 1957). The mortality in guinea-worm disease is low but the morbidity is very high. Many patients suffer from this infection almost every year, become bed-ridden, with much pain and discomfort, and are away from work for long periods. Removal of the worm by rolling it on a stick or by surgery has traditionally been acclaimed successful, but is both cumbersome and dangerous, and is unpredictably successful in a small proportion of cases. No effective medical treatment was available until Raffier, Oduntan et al. and Kothari et al. reported the successful use of niridazole.

An objection may be raised that the present trial was not strictly double-blind as one of the investigators knew the nature of treatment given to each patient. A strictly double-blind trial with niridazole is virtually impossible as the excretion of the drug produces intense red coloration of urine which the patient is keen to report. This was the reason why only the investigator who initially gave the randomized treatment inquired into the side effects produced in each patient. This investigator was thus likely to find out the nature of treatment given to any patient. He, therefore, took no part in the initial or the subsequent clinical assessment of local lesions.

This study confirms the results reported by us as well as those reported by others. In the niridazole group 91% of the patients obtained complete healing of their lesions. Of these 92% healed within 20 days and the rest within 30 days of starting treatment. In the placebo group the lesions healed in 45%, but in 89% of these patients it took 1-2 months before the healing occurred. In the placebo group apart from the delay in healing, 34% of the patients remained unchanged and 21% had deteriorated at the end of 2 months. ODUNTAN et al. (1967) reported more or less similar results in their untreated control group of 23 patients. The persistance of the lesions when left untreated, predisposes to marked fibrosis at the local site with a risk of developing contractures or joint deformities. A striking feature of this study was the rapid healing obtained with niridazole, without the use of sulphonamides or antibiotics, of severe lesions with cellulitis or abscess, where, in many instances, the organism responsible for the secondary infection was coagulase positive *Staphylococcus aureus* (KOTHARI et al., 1969).

Another interesting feature of niridazole treatment was the marked symptomatic relief obtained within 3-4 days of starting treatment, even in the absence of any apparent change in the local signs. Many bed-ridden or house-bound patients could walk about freely and attend to their work within 3-4 days.

The rapidity with which healing of lesions occurs with niridazole, irrespective of the extrusion or the retention of the worm, suggests that the drug acts directly on the adult worm, but its exact mode of action is not known. It may, however, be postulated that (a) it irritates the worm and causes its early spontaneous extrusion, (b) it paralyses the worm, thus minimizing its hold on the tissues, whereby it can be pulled out with remarkable ease—a fact noticed by many patients and the investigators, and (c) in many cases it kills the entire worm or its remnants *in situ*, thus obviating the necessity of removing it.

The incidence of the side effects in the present study was higher than in our previous report; they were generally mild, or moderate in a few cases. No neuropsychiatric side-effects (POWELL et al., 1966) were encountered, but in another study conducted concurrently in a different area, 2 patients showed neuropsychiatric side-effects. The first was a woman 50 years old weighing 36 kg. who was prescribed, through error, 500 mg. 3 times a day. On the third day of treatment she became disorientated, started muttering, developed jerky movements of right side of the body and exhibited marked tachycardia. She recovered completely within 24 hours of withdrawal of the drug. The second patient, a woman of 25 years, was prescribed niridazole 500 mg. 3 times a day, but owing to some misunderstanding she took 1000 mg. 3 times a day. She became excited and disorientated on the third day but showed complete recovery within 24 hours of stopping niridazole. In both these instances the drug administered was nearly twice the recommended dose and, in our opinion, the neuropsychiatric side effects were dose-dependent.

Another feature which may be stressed is the rather large number of patients (10 of 75) who discontinued the treatment. In another uncontrolled study 15 of 50 patients stopped taking niridazole after 1-2 days. This, we feel, is largely due to their passing dark red urine, which along with other minor side effects, frightens them. Secondly, as the selected patients in a field trial live in a very close community, in the event of one patient experiencing some side effects, patients living close by automatically stop taking any further treatment. This is borne out by the fact that some of the patients who received the placebo also complained of the same side effects as the patients given niridazole. In our experience all the patients who are admitted to a hospital and are under constant medical supervision invariably complete the treatment.

Summary

A double-blind trial with niridazole has conclusively shown the value of the drug in the treatment of dracontiasis. The therapeutic efficacy was evident from the rapidity with which healing occurred in more than 90% of the patients in the niridazole group. Although minor side effects were seen in a large number of patients, the acceptability of the drug was fairly high.

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18

DRACONTIASIS IN MAN: BIOLOGY OF THE WORM AND PATHOLOGY OF LESIONS

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Dracontiasis in man: Biology of the worm and pathology of lesions

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The guineaworm (or the medina-worm) is a tissue nematode. The species of guineaworm for which man is a natural host is called Dracunculus medinensis; it was also called Filaria medinensis (Filum-thread). The species-specific name medinensis is probably derived from the fact that the worm was first discovered and described in or around Medina. According to Belding (1965), Bastian described the morphology of the adult female parasite in 1863, and Fedtschenko observed the existence of the larvae in cyclops in 1870. It is only the adult female worm which is pathogenic in man. The adult male worm has been rarely seen and was not fully described till Moorthy (1937) isolated it from experimentally infected dogs. During our work on the guineaworm disease in the State of Maharashtra we observed certain features hitherto undescribed. This has prompted us to review the biology of the worm and relate the same to the pathogenesis and pathology of lesions.

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MORPHOLOGY

The fully grown adult female worm has a smooth cylindrical body, ivory-white in colour, measuring 60 to 120 cm. in length and 1 to 1.5 mm. in thickness (Fig. 1). In a gravid female, the body is filled up with a pair of uteri distended with about 3 million larvae (Fig. 2). The space occupied by the uteri leads to atrophy of the entire alimentary tract (Belding, 1965; Manson-Bahr, 1966; Lapage, 1968). The male worm measures 1 to 3 cms. by 0.4 mm. (Moorthy, 1937). A mature larva has a flattened, spindle shaped body, a rounded head and a slender long tail (Fig. 3). It measurs 500 to 700 microns in length and 15 to 20 microns at its greatest breadth (Belding, 1965; Manson-Bahr, 1966). The larvae exhibit constant movements within the body of the mother. Freshly isolated mature larva is a highly motile organism exhibiting undulating movements.

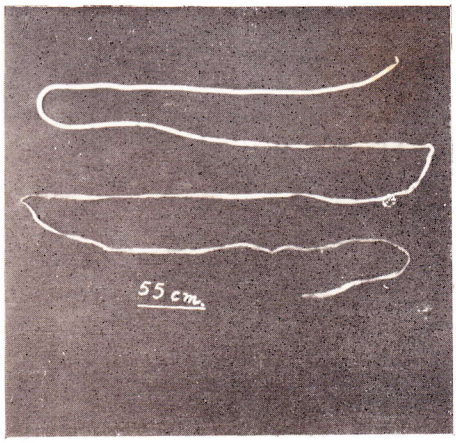

Fig: 1. Adult female guineaworm,

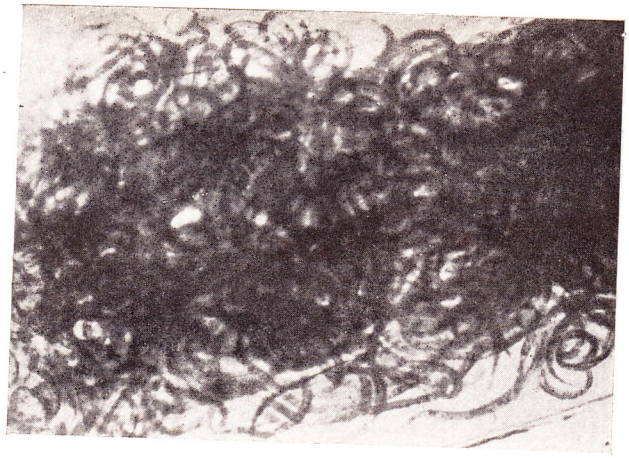

FIG: 2. A part of the gravid uterus packed with larvae.

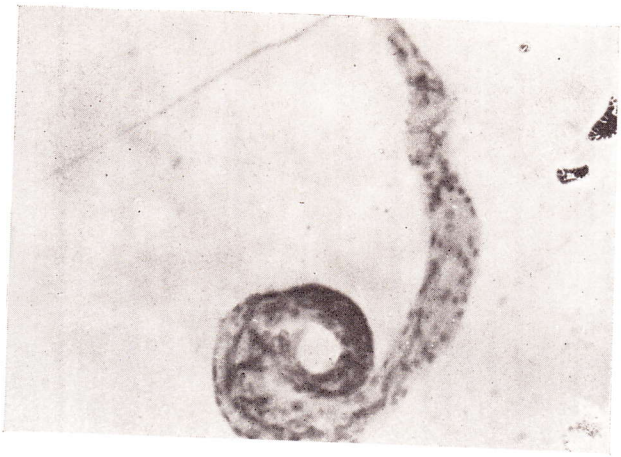

FIG: 3. A guineaworm larva.

LIFE CYCLE

Infection in man occurs by drinking water containing infected cyclops. Many species of cyclops have been identified as efficient intermediaries (Manson-Bahr, 1966). However, Mesocyclops leukarti and Mesocyclops hyalinus are the two most common species found infected with guineaworm larvae (Moorthy and Sweet, 1936). It has been postulated that hyperchlorhydria offers protection against the cyclops and the larvae (Moorthy, 1932; Parekh and Kulkarni, 1958; Scott, 1960). Gilles and Ball (1964) and C. Sita Devi *et al* (1969) however, found no such correlation. The dissolution of the cyclops releases the larvae in intestinal tract but the route of their further odyssey has not been established. Onabamiro (1956) has suggested lymphatics as the route of the metamorphosing larva from the alimentary canal to the subcutaneous tissues of the host. Manson-Bahr (1966) has classified the worm as a parasite of the lymphatic system. However, it has not yet been

reported to inhabit either the lymphatics or the lymph nodes.

Fertilization probably occurs in the retroperitoneal tissues (Manson-Bahr, 1966), the male dying and getting absorbed soon after copulation with a female of its own size (Moorthy, 1938; Manson-Bahr, 1966). The growth of the embryos occurs *pari passu* with the growth and the migration of the female. In a guineaworm obtained from a hernial sac in the inguinal region, it was found that most larvae were incompletely developed and stages from the 8-celled embryos to fully formed larvae were observed. On the other hand, the larvae from worms removed from the lower limb were all mature (Fig. 2). It is not yet clear how the mature adult worm and its larvae maintain their nutrition, withstanding the fact that in a gravid female the distended uteri lead to atrophy of the entire alimentary tract (Manson-Bahr, 1966; Lapage, 1968). We have often observed that the gravid female *in vivo* is surrounded by a rich exudate. Nutrition through surface absorption may therefore maintain the growth of the mother and the larvae.

The female worm discharges its brood into water through a lesion in the skin of the host. The larvae cannot swim in water (Manson-Bahr, 1966), sink to the bottom and are taken up by the cyclops, who advantageously cannot swim except near the bottom of the well or the pond (Moorthy, 1938). Infection in man, therefore, generally occurs in dry seasons when the well or the pond is almost scooped for water (Moorthy, 1938; Mason-Bahr, 1966). We have observed that in the State of Maharashtra, the highest incidence occurs between March and July of every year. The time between ingestion of larvae and the occurrence of clinical manifestations is 10-12 months (Moorthy, 1932; Chitwood, 1933; Manson-Bahr, 1966).

PATHOGENESIS

The attributes of a successful parasite are infectivity, invasiveness, pathogenecity and toxigenicity (Jawetz *et al* 1968). The guineaworm possesses all these features. In endemic areas it exhibits a high degree of infectivity and its odyssey from the intestinal lumen to the lower limb is the function of its invasiveness. Its pathogenicity is evident from the wide variety of lesions it gives rise to. However, its toxigenecity is poor and is manifested as the prodromal allergic syndrome. The life cycle of the female worm, in man, is well oriented towards having its large larval progeny discharged to the exterior through skin areas most likely to be in contact with water. This quality of hydrotropism leads to the occurrence of lesions in the region of the leg and foot in the rural people who go bare-footed, on the backs of water-carriers (Boyd, 1961; Manson-Bahr, 1966) and in our experience on the lower part of upper limbs in city dwellers. Boyd (1961) states that the worm usually appears on the sole of the foot in rural people. However, we came across only 2 lesions on the sole of the foot amongst 794 lesions in 500 patients. Apparently, the worm avoids being crushed under the weight of the body. An interesting exception to the hydrotropic behaviour of the worm is the rarity with which it seeks fluid-containing areas of the body. It has not yet been reported in the subarachnoid space nor in the lumen of the gut. Escape of the worms through the rectum under niridazole therapy has been reported (Raffier, 1965; Kothari *et al* 1970c).

The worm possesses powerful motility *in vivo*. This we have observed *in vitro*

as well. It secretes a powerful lytic substance which permits it to travel in the body of the host, from deeper to superficial planes as well as over long distances in the superficial planes. This lysin also helps to dissolve the derma, forming a blister, around the head of the emerging worm. As the migration of the worm from the deeper to the superficial parts of the body of the host is a silent and symptomless process, it may be inferred that the lysin, referred to, does not possess inflammatory or allergic properties. Active guineaworm lesions are characterised by inflammation and the factor responsible appears to be an irritant secreted by the worm. The existence of such an irritant has also been suggested by Belding (1965) and Manson-Bahr (1966). Fairley and Liston (1923) disproved the popular concept that the larvae constituted the irritant. The severity of the local lesion probably depends upon the amount of the irritant secreted. This may account for the remarkable waxing and waning of a dracontial lesion when followed up over a long perid. Another important aspect of the activity of the irritant is its ability to excite, especially in closed lesions, an intensely fibrinous exudate. This is responsible for the chronicity of dracontial lesions, formation of thick walled cysts, tendon contractures, ankylosis of joints, and rarely such lesions as constrictive pericarditis or periureteric fibrosis leading to hydronephrosis.

The worm behaves differently in closed and open lesions. As long as the lesion is closed, the worm lies relatively free and its extraction by a surgical incision or aspiration through a wide bore needle may be successful. As soon as the guineaworm lesion becomes open, the worm exhibits a powerful hold on to the tissues. Two spicules near its tail end have been described (Belding 1965) which probably serve as an anchoring agent. At a time, only a small length of the worm can be pulled out, the worm often snapping in the process. When the worm which is being pulled is suddenly released, it exhibits a powerful recoil and a rapid retreat into the wound. This frightening movement of the worm allows it to be rightly called the little dragon or the dracunculus.

ROLE OF SECONDARY BACTERIAL INFECTION

Secondary bacterial invasion of open guineaworm lesions has been held responsible for the acute inflammation and its complications. In our opinion the entire gamut of the clinical manifestations in dracontiasis is attributable to the irritant secreted by the gravid female. We feel that secondary bacterial infection plays no significant role in the morbidity of guineaworm disease. Our observations in favour of such a radical proposition have been described elsewhere (Kothari *et al* 1969b, 1970c).

IMMUNITY

There is a poor and ineffective immune response to guineaworm infection. Recurrent infection is, therefore, a rule rather than exception (Moorthy, 1932). Sandground (1932) has stated that age-immunity becomes particularly demonstrable when species compatibility of host and parasite is frankly low. In the experimental dogs, there is an increased resistance to guineaworm infection with increasing age suggesting that dog is an unnatural host for the adult Dracunculus medinensis.

PATHOLOGY OF DRACONTIASIS

a: Allergic syndrome—The occurrence of the allergic syndrome (prodromal symptoms) just prior to the appearance

of the local lesion; its absence in nearly half the patients (Kothari *et al* 1970,) and its mild short-lived nature indicate that the allergen is a weak substance, and the response varies from patient to patient.

The nature of the various prodromal symptoms and their incidence has been described elsewhere (Kothari *et al* 1970a).

b: Inflammation—Actute dracontial inflammation presents with local signs and symptoms unaccompanied by systemic clinical manifestations so characteristic of acute bacterial inflammation. The only consistent systemic manifestation, according to Moorthy (1932) is an increased eosinophil count (7 to 15%), a feature not commonly observed by us. Inflammatory lesions can be best described as open and closed. 80% of the lesions in the present series were open and presented as an ulcer or a sinus. Such a lesion usually started as a blister formed by the lytic activities of the worm separating the epidermis from the dermis. The blister was often surrounded by a zone of erythema or cellulitis. According to Manson-Bahr (1966), the blister fluid contains many larvae. Belding (1965) described the presence of mononuclears, eosinophils and neutrophils in the fluid. We have examined the blister fluid on several occasions and found serous or serosanguinous fluid containing red blood cells in rouleau formation and pus cells with the absence of larvae or any other cells.

Sinus: In the present study, 14% of the lesions were in the form of a sinus. A sinus was seen as a circumscribed lesion, 2-3 mm in diameter and often with an undermined edge. Till such time that the worm was completely discharged, manully removed or killed *in situ* by systemic niridazole therapy, a sinus often persisted as a cold, chronic lesion for many weeks.

Ulcer: This was the most common lesion seen in the present series (66%). An acute ulcer had punched out edges, pink granulation tissue lining the floor, a soft base and copious, serous or serosanguinous discharge. A chronic ulcer had thick, well-defined edges, pale floor, a thick base and scanty discharge, Occasionally, exuberant granulation tissue led to the formation of everted edges.

All the open lesions were colonised by bacterial organisms, Staphylococcus aureus coagulase positive being the commonest (Kothari *et al* 1969b, 1970b). Secondary bacterial infection, however, did not appear to play any significant role in the dracontial inflammation (vide supra).

Microscopically, an acute inflammatory dracontial lesion was characterised by the presence of lymphocytes, monocytes and polymorphonuclear leucocytes. An intense exudation in a closed lesion led to the formation of acute abscess containing typical guineaworm pus: thick, cream-coloured fluid with a mild odour and having sp. gr. 1018-1024; protein content varying from 4.2 to 6.0 gm. with albumin/ globulin ratio of 1:3 and containing large amount of fibrinogen which led to clotting on standing. Under the microscope, it presented numerous fibrinous strands and pus cells. No eosinophils or bacteria were seen and pus from closed lesions did not yield any organisms on culture.

Subcutaneous tissue (Fig. 4) and skin were the sites most commonly involved. Occasionally muscles, bursae (Fig. 5), joints (Figs. 6, 7), tendon sheaths (Fig. 8) and rarely bones were affected. Involvement of pericardium (Kinare *et al* 1962) testis and epididymis (Belding 1965) and extradural region (Reddy and Valli, 1967) have also been reported.

Chronic inflammatory lesions showed intense lymphocytic infiltration and fibro-

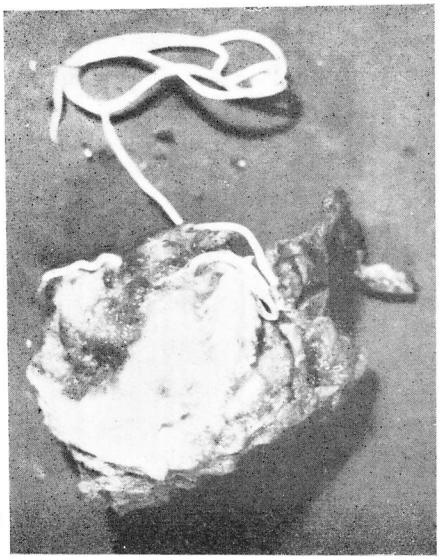

FIG: 4. Guineaworm cyst removed from a patient presenting with hydrocele of tunica vaginalis.

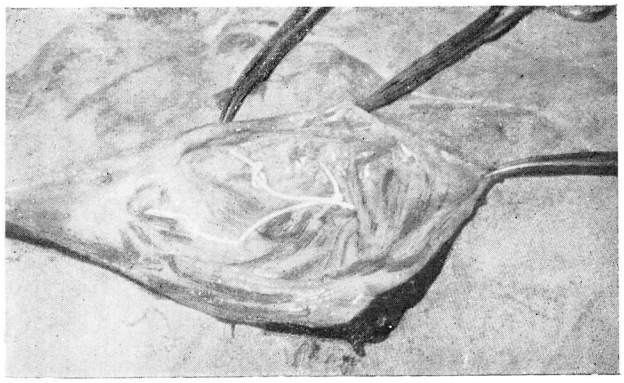

FIG: 5. Guineaworm as seen in prepatellar bursa. Note the multiple spontaneous knots along the length of the worm.

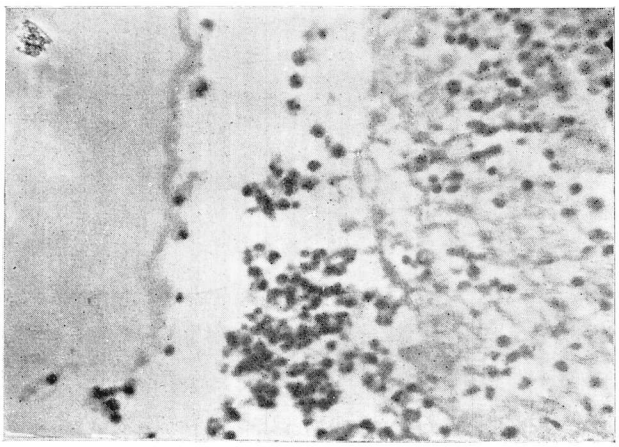

FIG: 6. Chronic dracontial synovitis in a female of 14 years. Patient presented with painless effusion of knee joint of 6 months duration, simulating tuberculous synovitis. Synovial biopsy clinched the diagnosis.

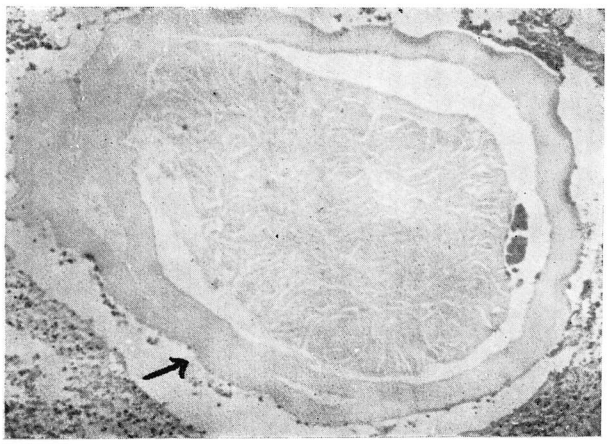

FIG: 7. A guineaworm in cross section can be seen in juxtaposition to the synovial membrane detailed in Fig. 6.

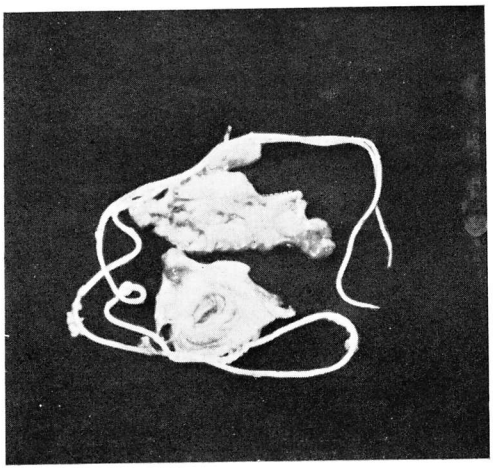

FIG: 8. This chronic dracontial cyst involved the sheath of the extensor pollicis longus tendon in a girl of 12 years with the pre-operative diagnosis of ganglion.

blastic proliferation. A large, chronic granuloma in the quadriceps muscle infiltrated over a wide area, was remarkably vascular and mimicked a sarcoma. The presence of guineaworm and the histopathology confirmed the diagnosis. Chronic inflammatory cysts showed thick walls presenting on the inner side, pale, velvety surface covered by numerous fine calcareous particles which were also present in the thick sticky, pastelike pus filling the cavity. Microscopically, the

cyst wall showed an outer fibrous and an inner cellular layer of granulation tissue often containing fragments of dead worm.

C: Aftermath: The healing by marked fibrosis of dracontial lesions at certain sites gave rise to tendon contractures and ankylosis of joints. Cutaneous scars resembled keloids. Calcification of the worm in the subcutaneous region (including the scrotum; Kothari, 1965) left palpable nodules.

SUMMARY

Biological features of Dracunculus medinensis are described and these have been correlated with the pathogenesis of dracontial lesions in man. The pathology of the various stages of guineaworm disease have been presented.

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