EXPERIMENTAL STUDY ON THE THERAPEUTIC INDICATIONS OF INTESTINO-CYSTOPLASTY IN NEUROGENIC VESICAL DYSFUNCTIONS

by

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PREFACE.

Intestino-cystoplasty has appeared for the past ten years as a satisfactory surgical procedure in varied pathological conditions. Several attempts were made to apply this operation to the treatment of neurogenic bladders. The results were generally not rewarding. It appeared to us that a different approach should be utilised and that a solution to this problem could only arise from the fundamentals of the physiology of micturition. A complete knowledge of the given pathological condition, the type and degree of neurological involvement of the detrusor and sphincterian system should have primary consideration in the discussion of this operation. Also, it seemed to us very important to try to determinate the surgical technique of intestino-cystoplasty which would be the most suitable according to the condition prevailing.

I am greatly indebted to Dr. D. R. Webster, who opened so widely the doors of the Department of Experimental Surgery to Urology.

I would like to express also my gratitude to Dr. K. J. MacKinnon and Dr. J. B. R. Cosgrove for their kind advice, keen interest and encouragement during the course of this study.

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CHAPTER I

INTRODUCTION

Attention has been drawn to the complex problem of the neurogenic bladder by the increased incidence of spinal cord trauma in civilian and war casualties. Improvement in the immediate care of the injuries has resulted in a greater initial salvage rate. The increased population of patients with neurogenic bladders suggests a need for re-evaluating the fundamental aspects of this problem. The physiology and pathology of the normal and neurogenic bladder have been studied. The utilization of substitute bladders in these cases has not been fully explored.

It has been established that intestinal cystoplasty represents an important step forward in urinary surgery. The advantage of reconstructive surgery has been re-emphasized for the past 13 years by a few pioneers such as Roger Couvelaire and Jean Cibert (12) and the method is now accepted by the majority. The use of this method in the treatment of neurogenic vesical dysfunction appeared particularly worthy of interest. Shoemaker and Lang (54) have described the good results obtained on dogs with ileo-cystoplasty after vesical denervation or sacral neurotomy. They underlined the advantage of using an ileal loop with intact parasympathetic innervation, to replace denervated bladder.

Numerous observations of entero-cystoplasties applied to the replacement of neurogenic bladder have been reported. These attempts met with variable success and did not produce very encouraging results. A systematic tabulation of the indications for this operation in this field appeared to be of interest.

It must be admitted that we have succeeded only partially in solving this particularly difficult problem.

CHAPTER II

HISTORICAL REVIEW

A. EXPERIMENTAL STUDIES

One of the first concerted approaches to the physiology of micturition and its relationship to the neurogenic bladder was made by Barrington (2). He described six separate reflexes. The first two complete their reflex arc in the brain stem. They are as follows: with increasing volume of the contents, the bladder contracts, and as the fluid forces the sphincter and runs through the urethra strong detrusor contraction occurs. Since the remaining four reflexes are found in the spinal animal, they can be said to have their neurons within the spinal cord. They consist of: a slight rise of vesical pressure following distension of the internal sphincter not sufficient to force the external sphincter; active relaxation of the urethra when it is passively distended; relaxation of the external sphincter whenever the bladder responds to distension by contraction of the detrusor muscle and relaxation of the plain muscle of the urethra by distension of the bladder spinal transection.

Following extirpation of the cerebral motor cortices bilaterally, Langworthy and Hesser (36) found that the vesical capacity was markedly decreased. The bladder lost its capacity to accomodate increased quantities of fluid at low pressures presumably due to loss of the inhibitory controls of these higher

centers. Although the former habits of micturition (such as urination in accustomed places) were lost, the animal assumed a characteristic posture with the beginning of flow of urine. Furthermore, it was found that defecation occurred with urination. Langworthy and Kolb (37) demonstrated that transection of the brain stem caudal to the acoustic colliculi resulted in a loss of vesical tonus and a loss of contractions sufficient to empty the bladder, i.e., retention with overflow incontinence. They concluded that the tone of the muscle in the bladder is controlled by mechanisms similar to those of striated muscle. In confirming Barrington's work, these authors also believed that abdominal contractions have a part in reinforcing micturition but are not essential. Dees and Langworthy (14) sectioned the posterior sacral roots in cats. Following this procedure normal micturition no longer occurred, the bladder enlarged to several times its original capacity and overflow incontinence developed.

Langworthy and Hesser (36) also studied the effect of sectioning the motor and sensory sacral roots. They found that after a variable period of time decreased bladder capacity and periodic micturition occurred. Previously Langworthy, Reeves, and Tauber (39) observed the influence of parasympathetic and sympathetic nerve fibers. Sectioning of the parasympathetic nerve fibers resulted in essentially the same type of vesical pathophysiology as did sectioning of the sensory and motor roots; by

contrast the sympathetics were found to be in no way essential to normal micturition. In 1941 Langworthy, Kolb, and Lewis (38) summarized their investigations and other related work in a classic study, "The Physiology of Micturition."

In 1945 Jacobson (34) presented an elucidating study of the effects of peripheral nerve lesions and spinal cord lesions in dogs. He detailed the physiology of the three types of neurogenic bladders. Sympathectomy was found to have no effect in the normal or neurogenic bladder. The autonomous bladder resulting from section of the pelvic nerves was found to be hypertrophied, hypertonic, and to have a large quantity of residual urine. Section of the sacral sensory roots produced an atonic, dilated, poorly-functioning bladder with overflow incontinence. Destruction of the cauda equina or sacral portion of the cord resulted inthe same type of bladder as did pelvic neurectomy. Following complete transection of the lumbar or sacral cord an automatic or reflex bladder developed, characterized by slight hypertrophy and intermittent partial emptying.

B. CLINICAL STUDIES

Our present understanding of the anatomy of the autonomic nerve supply to the pelvic organs is based on the meticulous dissections of Latarjet and Bonnett (41) in 1913, and Hovelacque (33) in 1927. The para-

sympathetic fibers derived from the second, third, and possibly fourth sacral segments form the pelvic nerve (nervi erigentes) which leads to synoptic connections in the pelvic plexus and in the bladder wall. The sympathetic fibers from the lower thoracic and upper lumbar segments of the cord form the preaortic and presacral plexuses. The latter forms the hypogastric nerves which lead to the pelvic plexus.

One of the earliest studies on the action of the urinary sphincters was done by Wesson, Macht, and Young (67). In 1920, they described depression of the internal sphincter and prostatic urethra by contraction of the levator prostatae and rectourethralis muscles, thereby straightening the curve of the prostatic urethar. According to these investigators, the bladder neck was opened by relaxation of the tonic contraction of the internal and external sphincter and by contraction of the trigonal muscles.

Classical experiments on the physiology of micturition in human beings were conducted by Denny-Brown and Robertson (13) in 1933. They found the reactionary contraction of distension of the bladder was controlled by an unconscious restraining effect at low volumes, but intruded upon the consciousness as the volume increased. When the threshold was reached, sensations of bladder fullness were perceived. Internal sphincter contractions and relaxations were found to be entirely secondary to activity of the detrusor muscle. The external sphincter was found to open only after the inter-

nal sphincter and appeared not to be relaxed by voluntary effort.

Denny-Brown (13) also studied 6 patients with cord lesions; three involved the cauda equina, and three involved the cord cephalad to the sacral region. Although two of the patients with cauda equina lesions suffered automatic bladders, subesquent investigators, (13 - 14 - 33 - 34 - 36 - 37 - 39 - 41 - 44 - 67) have doubted the completeness of the lesions. In the third patient an autonomous bladder developed. In the 3 patients with supranuclear lesions, neurogenic bladders of the automatic reflex type developed.

A most thorough study of sphincteric action in neurogenic bladders by Denny-Brown and Robertson (13) enabled them to conclude that after cord lesions the "internal sphincter" or bladder neck reflects a degree of contraction reciprocal to that of the detrusor, i.e., when the detrusor contracts the internal sphincter opens probably because of the arrangement of the muscle fibers. They believed the internal sphincter was not under separate neural control. The external sphincter was reflexly active where the sacral segments survived; this sphincter maintained a tonic contraction which was relaxed reflexly by a certain degree of active vesical contraction. More recently, Talbot (55) has brought the problem up to date by summarinzing the observed facts, and general laws of physiology together with his experience on a large series of paraplegic patients. He has

evolved a concept of the physiology of micturition providing a basis for reasonably accurate predictions which can be translated into a satisfactory system of clinical management.

C. TREATMENT OF NEUROGENIC BLADDERS

Treatment of the neurogenic bladder in the chronic stage has been divided into two schools of thought, the conservative and the surgical. Surgical or active treatment has been advocated by Emmett, (17 - 18 - 19 - 20 - 21) Thompson (59) and Nourse et al; (48) who have reported good results by applying transurethral resections to neurogenic bladders with significant residual urine. Munro, (47) Prather, (49) and others have championed the conservative method which consists primarily of tidal drainage and urinary tract antisepsis.

Talbot (55 - 56 - 57) has outlined a concerted and extensive program for bladder retraining and rehabilitation which embodied: 1)closure of all fistulas (accidental as well as suprapubic), 2) eradication of infection, 3) transurethral resection for demonstrable bladder neck obstruction and 4) development of adequete bladder capacity with minimal or negligible residual urine through a carefully controlled training period. In this training period every effort was made to establish voluntary bladder control by conditioning. Tidal drainage was instituted immediately after the trauma while the bladder was still in a state of spinal shock; by adjustment of

the syphon levels, the development of excessive degrees of hyper-tonicity was avoided or minimized. By meticulous attention to these and other conditioning techniques the intermittent partial emptying of the automatic reflex bladder may be modified and reinforced. Eventually, control of micturition is achieved by training the patient to void voluntarily, anticipating the involuntary reflex emptying of the bladder. In a series of 100 consecutive unselected paraplegic and quadriplegic patients, most of whose lesions were complete, Talbot (57) reported satisfactory results with adequate bladder control in 78 per cent.

Several neurosurgical procedures have also been investigated. Munro (47) has advocated anterior rhizotomy of the lower thoracic and lumbar nerves for spastic reflex contractions of the lower extremities and for reflex abdominal contractions thought to cause or contribute to vesical irritability (i.e., spastic reflex bladder). Hoen (32) first proposed bilateral block or section of the third sacral root for selected cases of retention. The value of this procedure was subsequently confirmed by Heimberger et al. (31) Sheldon and Bors (51) studied the effect of subarachnoid injections of alcohol in patients with complete supranuclear lesions. Bors (4) also used pudendal nerve sections in order to relax the spastic external sphincter. He also suggested temporary nerve blocks and spinal anesthesia not only to predict results of the permanent procedure but also as a definite treatment. It was the opinion of Bors that the residual

urine decreases in proportion to bladder capacity with the acute conversion of a supranuclear lesion to an infranuclear lesion. Furthermore he found that the bladder became more amenable to external pressure. Emmett (21) concurred with Bors in stating that "... a nonreflex bladder usually is a more serviceable one and can be treated more successfully than the inefficient reflex bladder."

As early as 1930 Learmonth (42) performed presacral neurectomies; Cheetham (6) has advocated this procedure. Meirowsky et al. (45) suggest anterior rhizotomy and neurectomy in selected cases, after preliminary sacral block or spinal anesthesia. These authors report good results which they attribute to relaxation of the perineal muscles and lowering of the vesical neck.

The vesical lesions resulting from spina bifida have been notoriously unresponsive to therapy. Talbot feels that the conservative method should be instituted as early as possible. Emmett (16) reported satisfactory results in only 20 per cent of these patients, following transurethral resections. Young (68) has utilized the technique of retropubic wedge resection converting a Y incision into a V to decrease vesical neck obstruction. After experimenting with various methods of colostomies, Gross, Holcomb, and Swan (28) concluded that the most efficacious approach was that of permanent suprapubic cystostomy.

D. FUNCTIONAL ANALYSIS OF THE BLADDER AFTER ILEOCYSTOPLASTY

The experimental use of bladder substitution was first reported by Tizzoni and Foggi (60) in 1888, but the clinical results in that period were poor. However, recent clinical and experimental applications as reported by Couvelaire (11) and Cibert (7) in France; Tasker, (58) Pyrah, (50) and Wells (66) in England; Freitas and Sadi (24) in Brazil, and Ferris (22) and Shoemaker and Marucci (53) in the United States are promising. These investigators used different techniques for ileocystoplasty. In some instances the isolated segment of ileum was anastomosed to the bladder as an open sheet, in the majority a closed tube was anastomosed to the bladder in varying positions. Hanley (29) has noted that urine is retained in the closed types of reconstruction. It would appear that an open patch of ileum would empty itself more efficiently. However, the reconstructed bladder must not only be able to empty, but must also be able to contain urine in a physiologic manner, at low intravesical pressures and with minimum reabsorption of electrolytes.

E. THE CHOICE OF COLON OR ILEUM

Modern methods of pre-operative preparation have made the surgery of the colon as safe as that of the ileum. If colocystoplaty gives better functional results than ileocystoplasty there are many reasons for adopting it. The sigmoid colon is close to the bladder, it has

a redundant loop and it can be mobilized easily. There is less chance of stenosis after restoration of its continuity than there is in the ileum, and a rectal tube can be passed up beyond the anastomosis to relieve post-operative distension.

Grégoire (26), comparing the physiology of the colon with that of the ileum, considered that the former was more suitable as a bladder reservoir and the latter as a ureteric conduit. Morales and his colleagues (46) have pointed out that micturition and defaecation depend upon identical reflex mechanisms with centres in the sacral part of the spinal cord and efferent fibres in the pelvic nerves. Gil Vernet and Gosalvez (62), reporting on 22 cases of colocystoplasty, considered it much superior to ileocystoplasty in its immediate and late results; the urinary stream was more powerful and residual urine never more than 20 ml. Küss (35) described his results in 20 cases of colocystoplasty and claimed that many of them passed urine normally with an excellent stream and residual urine less than 50 ml. He preferred the operation to ileocystoplasty as much for the simplicity of the post-operative course as for the quality of the subsequent micturition. J.P. Bourque (5) shares the same opinion and reported recently more than 40 cases with satisfactory results.

CHAPTER III

A. NOTES ON PHYSIOPATHOLOGY OF NEUROGENIC URINARY DYSFUNCTION AND THEIR RELATIONSHIP WITH THE THERAPEUTIC INDICATIONS OF INTESTINO-CYSTOPLASTY

1. Balanced micturition is directly proportional to the strengh developed by the detrusor (D) added to the intra-abdominal pressure (AP), and inversely proportional to the sum of resistance of the vesical neck (VN), external sphincter (ES), and the urethral canal (UC). The urethral resistance depends on the calibre and the length of the conduit according to the law of Poiseuille. The following formula could therefore represent the constant rate of micturition:

$$\frac{D + A.P.}{VN + ES + U} = K$$

when one of these factors is pathologically modified, it is necessary to adjust one or more of the other factors if the balance of micturition is to be restored. This is most strikingly illustrated by the excellent result often obtained with the transurethral resection of the vesical neck in the presence of a hypotonic bladder. This operation is often necessary as a complement to intestino-cystoplasty.

2. In case of neurogenic urinary dysfunction, combined lesions of the various elements of the ratio of micturition generally exist. The resulting therapeutic difficulties are all the more important as the exact mathematical evaluation of these factors is impossible. It is generally recognized that the cystometric and sphincterometric studies are inherently inaccurate.

There is a variety of clinical aspects: Atonic detrusors or, on the contrary, spastic bladders with non-reflex disorganized contractions blowing pseudo-diverticuli instead of associating for a complete drainage of the reservoir.

Funnel-like vesical neck, or on the contrary, hypertrophied and obstructive.

Flaccid or spastic perineal muscles.

3. Let us review briefly the principal medical and surgical means presently available to us for the treatment of neurogenic vesical dysfunction. Thus we shall be able to define the place of intestino-cystoplasty.

(a) <u>To modify the condition of the detrusor</u>

i) <u>In case of hypertonicity or spasms</u>

Parasympatholytic drugs are much utilized for the treatment of vesical spasms and many patients with frequency and urgency of micturition are considerably improved with the regular use of these drugs. In other cases this therapeutic measure fails. They are either unable to control the spasms or they result in urinary retention. In these cases, different types of neurotomies may be indicated such as bilateral sacral neurotomy, lombo sacral anterior rhizotomy or alcoholization. Some have been reported as being successful in a few instances where they actually restore normal urinary function. A bilateral sacral neurotomy seems contra-indicated, however, in case of vesico-urethral reflux. The Crede manoeuvre which is always necessary after this operation would cause repeated episodes of acute renal infection necessitating the use of an indwelling catheter. This was recently observed by the author.

The other two procedures are only justified when the release of a spasmodic condition in the legs is indicated.

Here again, the presence so often noted of reflux and vesical infection can prevent vesical rehabilitation and necessitate the use of a catheter. At least, the catheter will be tolerated more easily since the vesical spasms have disappeared. However, in numerous cases, if the lesions of the detrusor constitute the main feature a sacral neurotomy would be justified. Still, this is possible only when the sexual function is already lost. If the sexual function is preserved, such operations are generally to be avoided.

We have not mentioned the pre-sacral neurotomy whose effects on the micturition and vesical spasms are not ascertained. We believe it bears out the same contra-indications with regard to the sexual function.

Finally, there are irreversible vesical lesions in the first place: contracted, thick, infected bladders where it is doubtful whether any neurotomy would increase the capacity.

In all these various possibilities, the replacement of the detrusor would

eventually give a better chance of urinary rehabilitation.

ii) <u>In case of atonicity</u>

The therapeutic means are even fewer as regards the atonic bladder. Parasympathicotonic drugs are often of no avail, and do not offer a permanent solution. The partial cystectomy has never produced any definite results. In some cases, however, the Crede manoeuvre could be used with some success when diminished resistance of the external sphincter is an associated condition. Here again, the presence or the secondary development of vesico urethral reflux is often a contra-indication to this manoeuvre. Could these atonic bladders with a large volume of residual urine not benefit from intestino-cystoplasty?

(b) <u>To modify the resistance of the vesical neck</u>:

In order to re-establish a balance of micturition, it is also possible to modify the resistance of the vesical neck by resection, and this is very commonly used particularly in the treatment of the lower motor neuron

lesions, or else by diminishing the calibre, or by stretching it by means of a plastic procedure. The latter may appear logical, but is still in the experimental stage. The work done on this subject by Jack Lapides (40) is very interesting in this respect.

In many cases, a vesical neck resection is not sufficient to allow a satisfactory vesical evacuation, and the replacement of the reservoir is necessary. The fact that the neck has been previously resected does not constitute a contra-indication to the intestino-cystoplasty since in most cases, a resection has to be performed anyway following this operation.

(c) <u>To modify the resistance of the pelvic floor</u>

The increase of the external sphincter resistance, or more generally of the perineal muscles, is a purely theoretical notion. On the contrary, it is quite feasible to reduce this resistance either by using anesthetic blocks of the internal pudendal nerves, which according to Bors (4) have given lasting results, or by performing a uni or bilateral internal pudendal neurotomy. Needless to say, an extensive rhizotomy

or a sub-arachnoidial alcoholization would result in complete flaccidity of the perineal floor muscles. We believe that the condition of the muscles constitutes an important element as regards the indication of intestino-cystoplasty. Many possibilities can be encountered:

i) Presence of a completely flaccid striated sphincter, as found in the majority of Spina bifida patients. There is very little chance of achieving urinary continence in these cases, due to the frequency of an associated atonic vesical neck. This does not exclude, however, the possibility that the vesical neck may be normal, allowing this operation, although such cases are rarely encountered.

ii) On the contrary, in the lesions of the central neuron, the perineal floor is spastic. When this spasticity is very marked, like after a complete medullary section, there are too many obstacles to micturition to expect any result from an intestino-cystoplasty. However, would it not be possible to anticipate a satisfactory drainage of the neo-bladder after anesthetic blocks or secondary internal pudendal neurotomy? This remains to be demonstrated.

iii) These two extreme cases: complete flaccidity or intense spasticity of the external sphincter seems to constitute a contra-indication to intestino-cystoplasty. However, in numerous cases, the sphincter is only hypotonic or spastic to a lesser degree, and a cystoplasty in these cases might ensure the recovery of a normal urinary function as well as continence. This fact shows the advantage of an exact estimation of the sphincter tone and the value of an electromyography of the perineal muscles.

iv) The theory of urethral resistance recently by Jack Lapides (40) must certainly be considered when the indications for a cystoplasty are discussed. This concept suggests the fact that it would be easier to achieve urinary continence for a long urethra such as the male urethral canal than for the short female one. It is true that only females develop stress incontinence and not always for the only reason that their perineum is more exposed to trauma. If this opinion were confirmed, it would mean a better chance of continence in male than in female patients after intestino-cystoplasty. This is of practical importance when such an opera-

tion is planned, and the external sphincter is hypotonic.

Considerations of the above inspired our experimental study of this problem.

B. EXPERIMENTAL DATA

44 dogs were used in this experiment. In the first stage, a neurogenic bladder was created. In the second stage, an intestino-cystoplasty was performed.

1. Production of an Urinary Dysfunction

Three different types of nerve lesions were produced surgically with a view of creating urinary conditions most frequently encountered in human pathology. These include peripheral autonomous non-reflex bladder, central automatic reflex and a tonic bladder due to posterior root lesion. In all cases, the approach to the conus terminalis and cauda equina was through a lombo-sacral laminectomy under Pentothal anesthesia, and intracheal intubation.

(a) Anatomical Comment

The dog has three sacral nerves (Fig. 1), the first two passing through two sacral

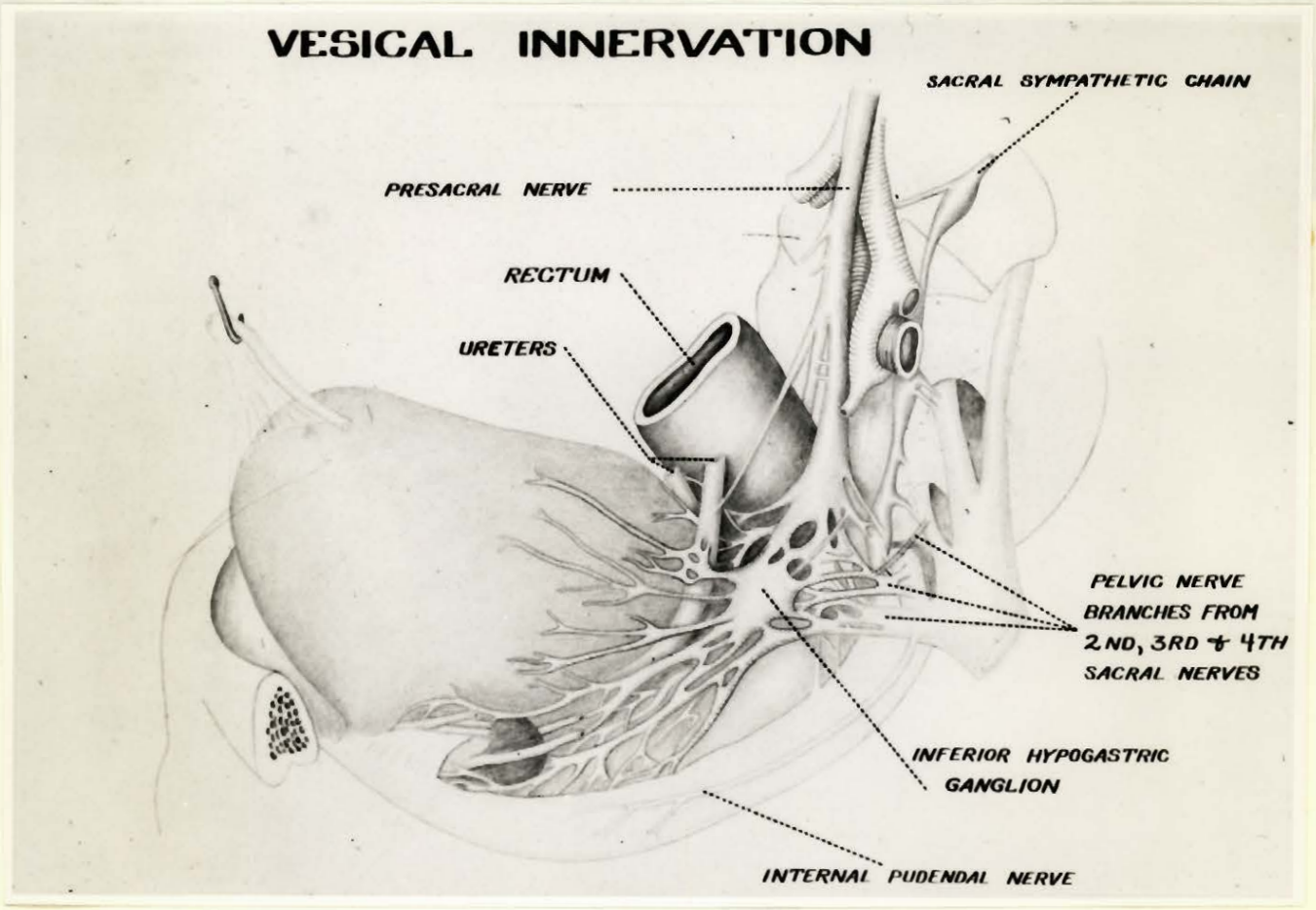
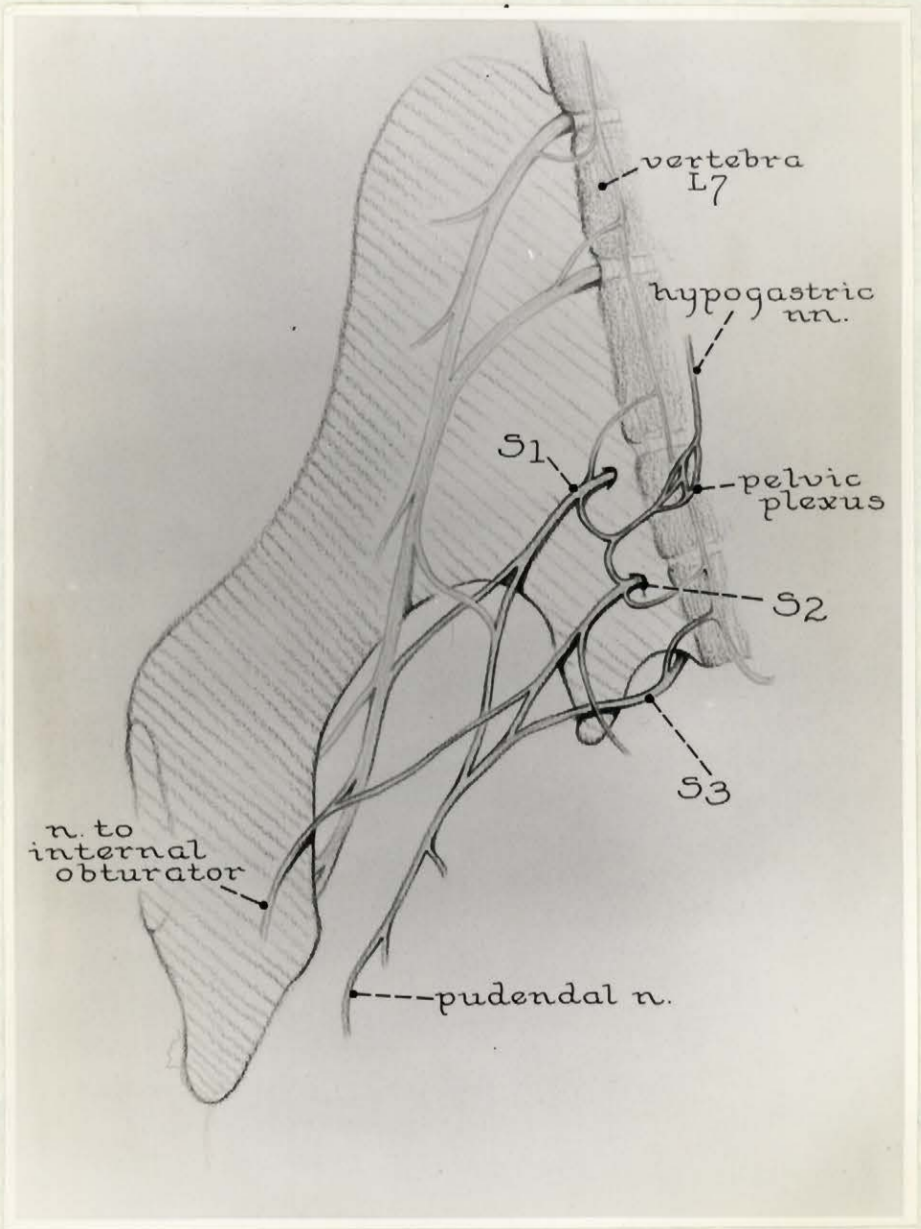

VESICAL INNERVATION
SACRAL SYMPATHETIC CHAIN
PRESACRAL NERVE
RECTUM
URETERS
PELVIC NERVE
BRANCHES FROM
2ND, 3RD & 4TH
SACRAL NERVES
INFERIOR HYPOGASTRIC
GANGLION
INTERNAL PUDENDAL NERVE

FIG. I



Sacral plexus in dogs

foraminae, and the third one reaching the pelvic cavity below the sacrum. The interior and posterior roots can be individualized only inside the dura. The dog has seven pairs of lumbar nerves, the seventh lumbar nerve being easily recognized from the first sacral nerve :

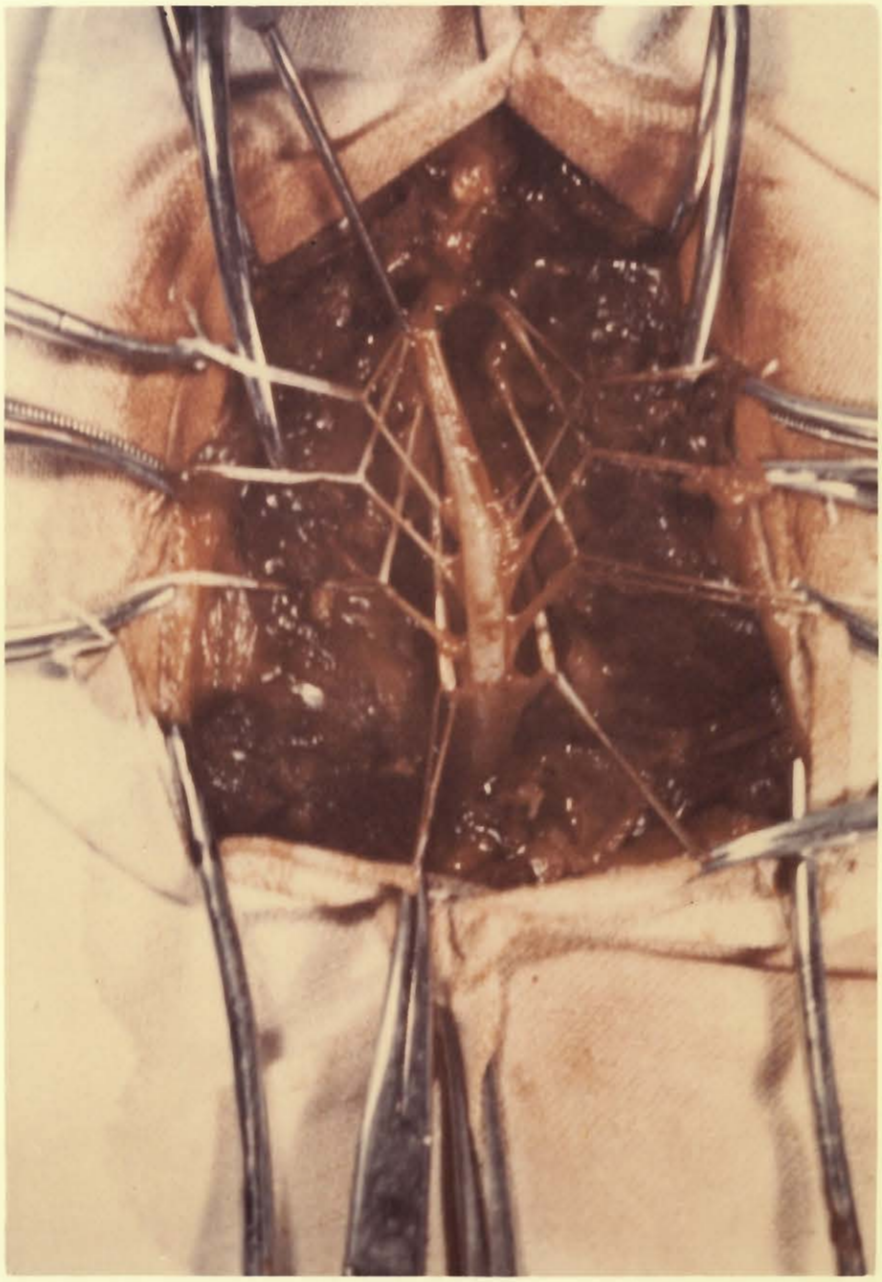
- by a better individualization of its posterior and anterior roots at the exist of the dura,
- by its distinctly larger size and
- by the presence of posterior ganglia.

There are 2 or 3 nervi erigentes, but the third one is often missing. The one arising from the first sacral nerve is always far larger in size and is always easy to individualize.

(b) <u>The following three techniques have been used</u>:

i) 17 dogs were submitted to a bilateral sacral neurotomy (Fig. 2) on the first, second and third sacral nerves with complete section of the anterior and posterior roots. The dura was not opened in this case. 9 males and 8 females were operated in this manner.

FIG. II



Conus terminalis - The 3 sacral nerves -
The 7th Lumbarnerve

(ii) Bilatéral section of the posterior roots of the three sacral nerves was performed on 13 dogs: 7 males and 6 females. For this purpose, the dura was opened and the posterior roots carefully dissected and severed. The motor anterior roots remained untouched.

(iii) A complete section of the spinal cord (Fig. 3) was made between the seventh lumbar segment and the first sacral segment with a view of creating a lesion of the central neuron and an automatic reflex bladder. 14 dogs, 10 males and 4 females were submitted to this latter procedure. L7 and S1 were carefully dissected. Then the dura was opened and the two nerves were followed up to their point of insertion in the cord. The section was made immediately below the insertion of the 7th lumbar pair.

C. RESULTS (Fig. 4)

1. The operative mortality was 50%. 22 dogs died during the first two weeks following the anesthesia mainly due to respiratory infection which antibiotics could not control. The dogs of the first and especially the third group developed

Conus terminalis - dura opened
First sacral nerve - Seventh lumbar nerve

FIG. IV

FIRST STAGE OF THE EXPERIMENT

PRODUCTION OF A NEUROVESICAL DYSFUNCTION IN 44 DOGS

A. THREE TECHNIQUES USED :

a) Bilateral sacral neurotomy of the 1st, 2nd & 3rd sacral nerves of both motor and sensory roots

		Male	Female
LAMINECTOMY - DURA NOT OPENED.	1) Number of operations	9	8
Dogs still alive for late Assessment		3	5

b) Bilateral Posterior Root Section: of the 1st, 2nd, 3rd Sacral Nerves.

	2) Number of operations	7	6

LAMINECTOMY - DURA OPENED.

Dogs still alive for the Assessment		4	5

c) Spinal Cord Section - Transection between L-7 & S-1 Segment To prevent Extensive Paralysis

	3) Number of operations	10	4

LAMINECTOMY - DURA OPENED.

Dogs still alive for late assessment		3	3

B. RESULTS ON 22 DOGS ... 2-3 MONTHS AFTER THE NEUROTOMY

	Atonic Bl	Autonomous Bl	Uninhibited Bl	Anal Sphincter Tone: Atonic	Normal	Increased
After Sacral Neurotomy	5	3		5	3	
After Post Root Section	6	3		6	3	
After Spinal Cord Sect.	2	3	1	4	2	

No Automatic Reflex Bladder Obtained.

paraparesis which in most cases improved satisfactorily. Two dogs, however, remained completely paralyzed and had to be sacrificed.

2. The following methods were used to evaluate the consequence of the nerve sections:

(a) Clinical Observations

- Presence or absence of urinary incontinence
- Presence or absence of vesical distention (A distended bladder is easy to palpate in dogs)
- Presence or absence of postural reflex during micturition in males as well as in females.

(b) Determination of residual urine

(c) Cystometrogram

(d) Study of the anal sphincter tone and of the bulbo-cavernosus reflex.

Two to three months after the neurotomy, complete reassessment prior to the second stage, revealed the following :

(a) A completely atonic bladder with overflow vesical distension and loss of postural reflex, also characterized by a typical

tracing and absence of vesical sensations, was found in 13 of these 22 dogs. Among the 13, 5 underwent bilateral sacral neurotomy, 6 a section of the posterior sacral roots, and 2 a medullary section.

(b) The presence of an autonomous non-reflex bladder, same as those encountered in the lesions of cauda equina, was noted in the 9 remaining dogs characterized by involuntary micturition and loss of postural reflex, a variable amount of residual urine, and uninhibited vesical contractions as demonstrated on the cystometric curve. 3 dogs presented this condition in each of the operated groups.

(c) Only one dog developed the type of bladder usually found in lesions of the central neuron, that is to say (i.e.) an uninhibited bladder with almost complete loss of vesical capacity (only 30 cc.). This dog had a medullary section between L7 and S1.

(d) It is preferable to examine separately thhe consequences of nerve sections on the anal sphincter as this is very important in drawing the conclusions of this experiment. 15 of these dogs presented fecal incontinence.

Of these, 5 underwent a bilateral sacral neurotomy, 6 a posterior radicotomy, and 4 a medullary section. 8 of these 15 dogs had a normal anal sphincter upon examination, as regards continence. An electromyography of the external sphincter did not seem necessary due to its technical difficulty in dogs.

D. DISCUSSION

It is quite obvious that part of our purpose, i.e. the obtention of a spastic external sphincter and perineal muscles, with automatic reflex bladder, could not be achieved. Two explanations are possible:

First of all, there was not enough delay between the medullary section and the final examination for the development of spasticity, or more possibly, and this is what has discouraged us from waiting any longer: the medullary section was too low and to complete, resulting in a lesion of the anterior spinal artery and necrosis of the conus terminalis.

This was observed in some post-mortem examinations. The reason why we did a low section was to preclude complete paralysis of the animal, which would have represented a technical difficulty insofar as caring for the dog.

CHAPTER IV

A. INTESTINO-CYSTOPLASTY

4 different techniques of entero-cystoplasty were used on the 22 surviving dogs 2 or 3 months after neurotomy. In all cases, a sub-total cystectomy was effected 2 cms. from the urethral orifices and descending anteriorly to the vesical neck in a racket-like fashion. Whatever technique was employed, the intestinal segment was sutured to the trigone using a simple continuous suture of 00 chromic catgut on all thickness of the trigone and the intestine. Two rubber drains were placed along the suture line and removed on the 8th day only.

The necessity of employing small calibre catheters (№ 8 or 10 maximum) with the male dog, easily obturated by the intestinal mucus, required a suprapubic vesical drainage which was generally well tolerated.

The Pezzer tube was with drawn on the 7th day, and the suprapubic sinus closed without difficulty with or without urethral catheter. Needless to say, it was necessary to sew the new intestinal bladder very carefully to the anterior abdominal wall around the cystostomy tube in order to prevent an extravasation which the intra-peritoneal location of the bladder would have made inevitable. The post-operative treatments consisted of daily vesical irrigation with neomycin solution, (0.5%), and intra-muscular injections of 2 million units

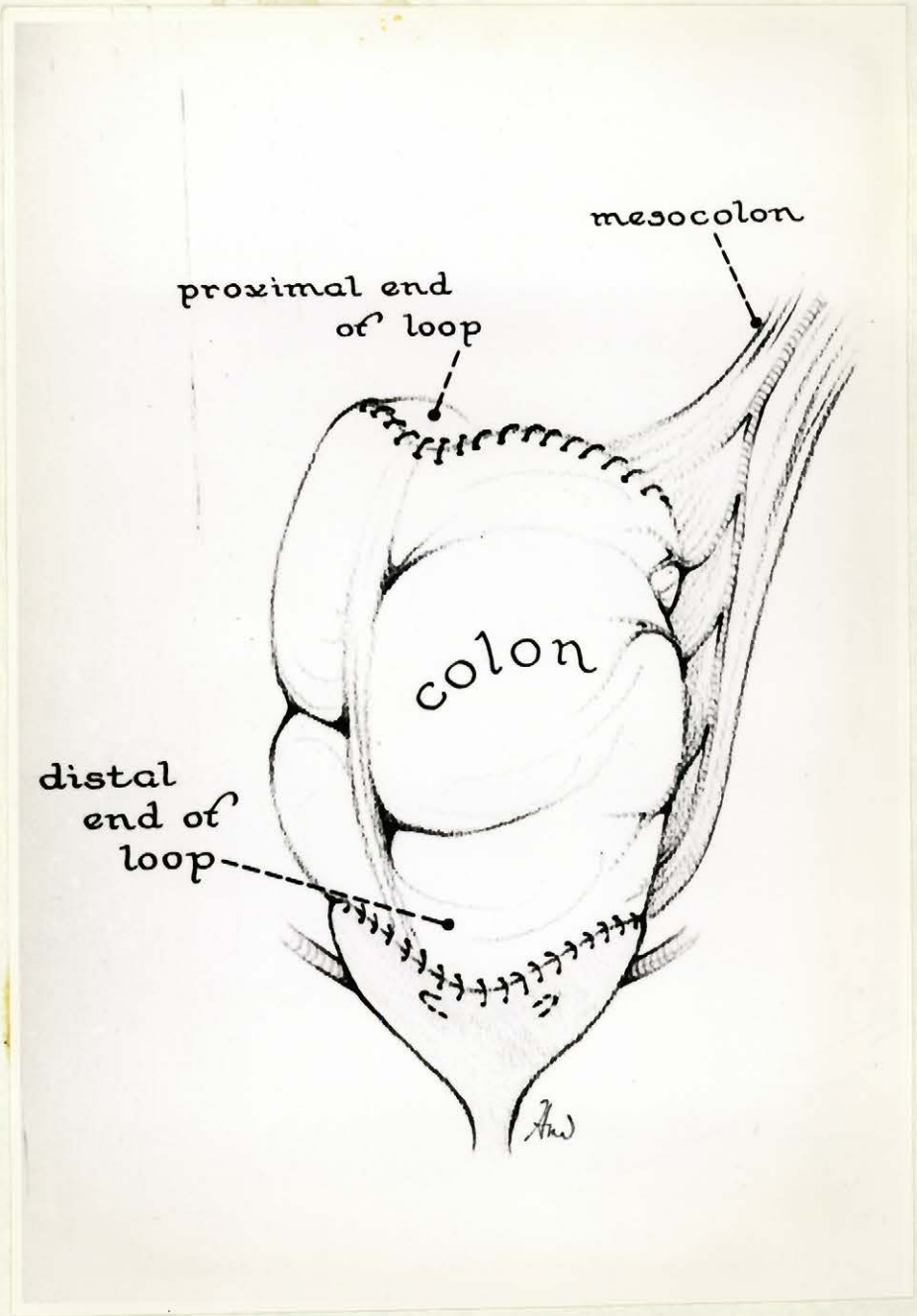
of penicillin, and of one gramme of streptomycin for a period of two weeks. The dogs were kept in cages and received no food during the first two days following the intestinal resection. A systematical intestinal disinfection with one gramme of neomycin and 2 grammes of sulfasuccidin was carried out during the three days preceding the operation. A strong cathartic was used on the eve of the operation, and an enema was given one hour pre-operatively. Anesthesia was practised with Pentothal, under tracheal intubation, and 250 cc. of blood were administered to each dog during the procedure.

1. A colocystoplasty was carried out on 9 dogs (6 males and 3 females) (Fig. 5). A 14 cm. segment was isolated from the descending colon. In some cases, an atonic dilatation was noticeable in the lower part of the descending colon in contrast with normal activity above this region.

   It was obvious that the colic segment had to be resected at the level of this active part. The colon was reanastomosed in two layers by an end-to-end method. The proximal extremity of the isolated segment was carefully closed, its distal extremity was cut in an elliptic manner in order to widen the surface of anastomoses, and sutured directly to the trigone.

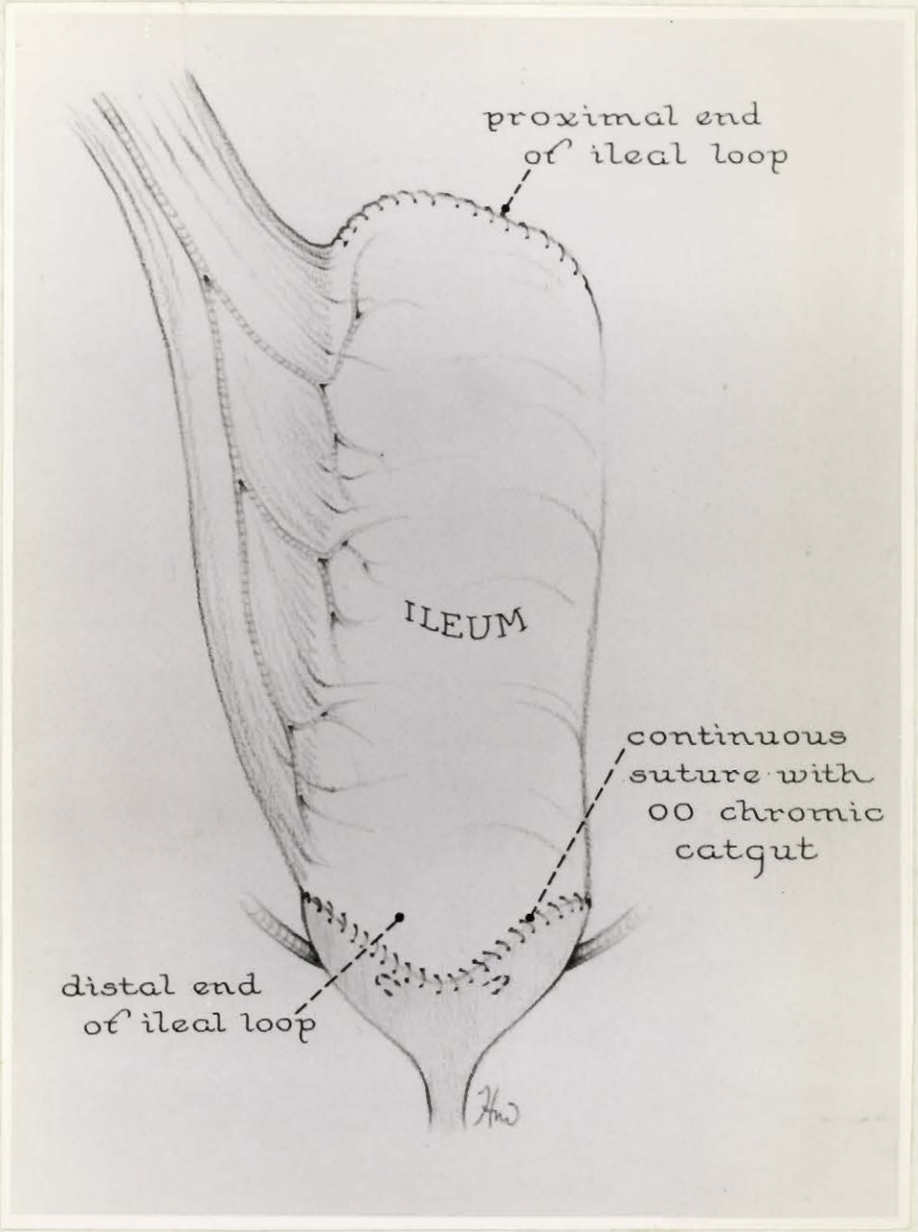
2. An ileo-cystoplasty was performed in 6 dogs (Fig. 6). A loop of approximately 18 cm (in length) was resected from the ileum at about

FIG. V



Colocystoplasty

FIG. VI



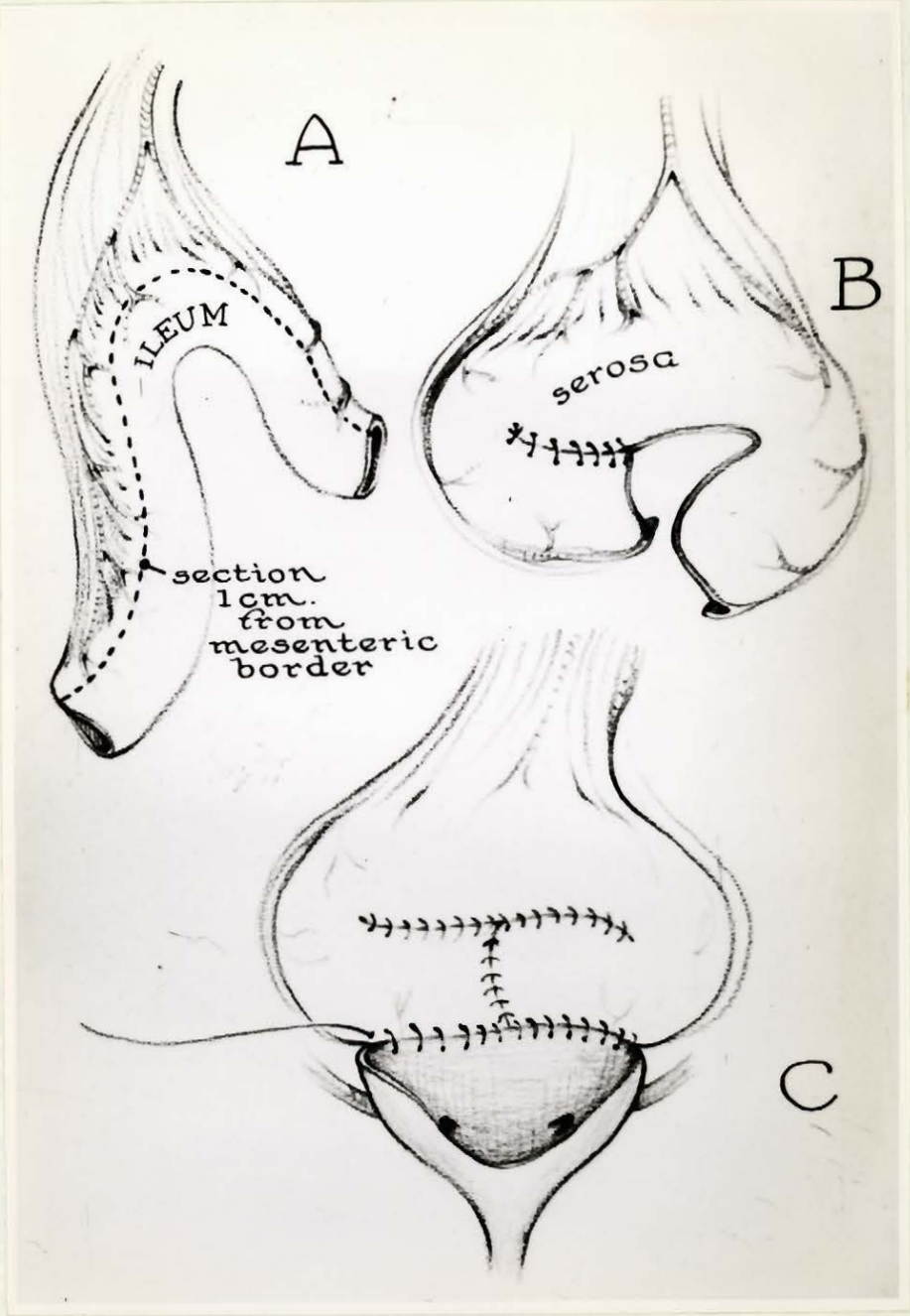
Ileocystoplasty

15 cm. from the ileocoecal junction, and the ileum was reanastomosed by the end-to-end technique. The proximal extremity of the ileal segment was closed, a cut of approximately 4 cm. in length was made at its distal extremity along the antimesentric border in order to enlarge the surface of anastomoses. This was done in the same manner as for the colon.

3. In 6 dogs, the ileo-cystoplasty was performed with a patch-like mucosa-free segment, in which the serosa formed the intra-vesical layer, using the Shoemaker technique (Fig. 7). To do so, a 40 cm. segment was resected and opened throughout its length, 1 cm. from the mesenteric border. It was easy to strip off the mucosa with scissors and gauze. The Peyer plaques were carefully scraped with a bistoury. A clamp was placed on the mesenteric pedicle during the dissection of the mucosa. Gauze impregnated with thrombase was then left in contact with the sub-mucosa for a few minutes after the clamp was removed. Thus, bleeding was moderate. A continuous suture of 00 chromic was employed for the fashioning of the patch, and suturing it to the trigone.

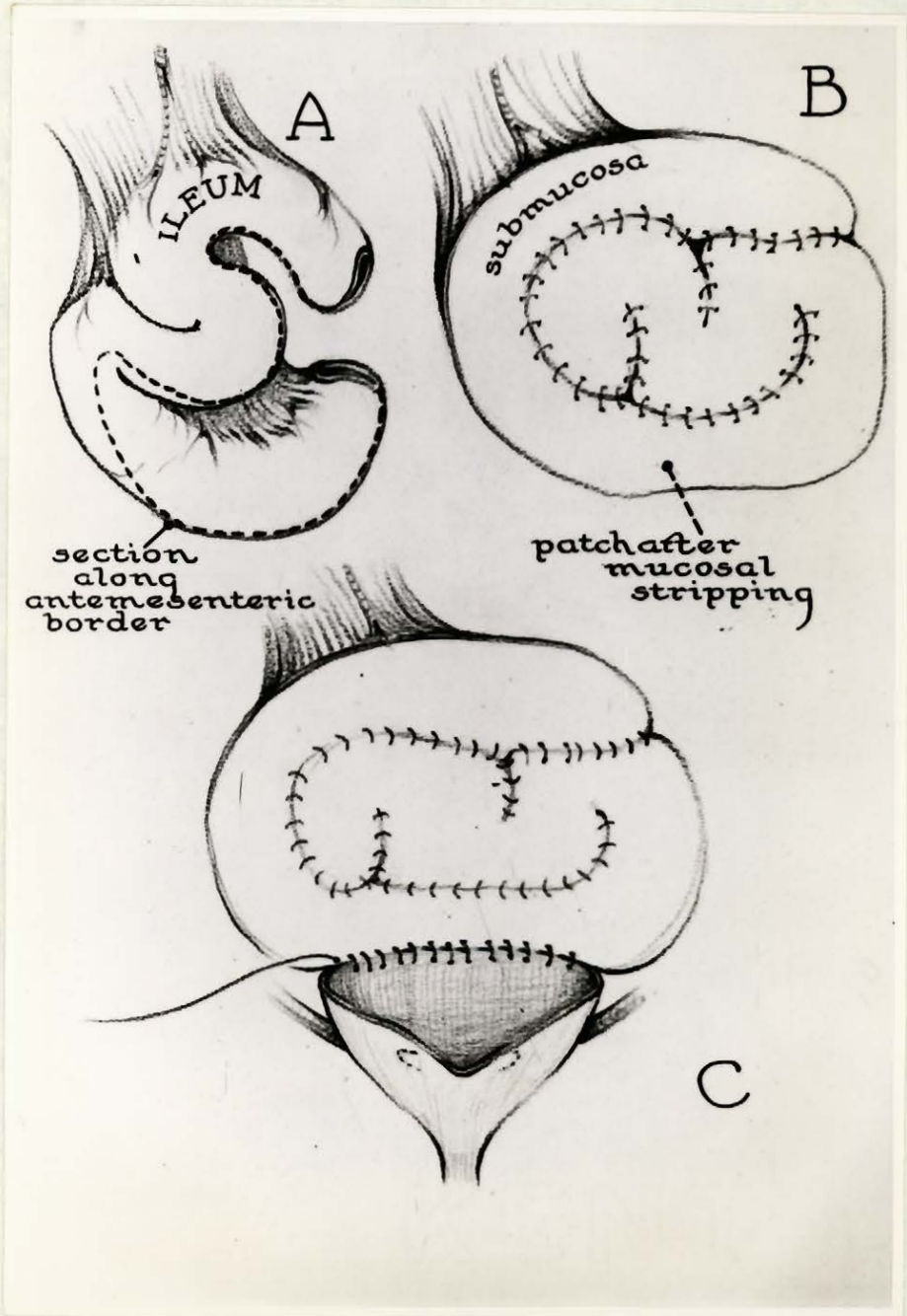
4. One dog only was submitted to a new technique of ileo-cystoplasty (Fig. 8). As previously, 40 cm. of ileum was used and opened, the mucosa was

FIG. VII



Reversed sero-muscular ileal graft

FIG. VIII



Denuded sero-muscular ileal graft

stripped off and fashioned as a patch. It differs from the Shoemaker's technique (53-54) by the following points:

(a) The intestine is opened along its anti-mesentric border.

(b) The sub-mucosa or muscularis forms the interior of the vesical wall instead of the serosa as in the previous case.

(c) The patch is differently and more easily modeled due to the fact that the mésentery does not have to be twisted as in the other technique.

B. RESULTS OF THE INTESTINO-CYSTOPLASTY (Fig. 9)

Only 11 dogs survived the operation. Final evaluation of the results was made between 2 to 7 months, or an average of 5 months, after the operation. These results were classified by the following criteria:

(a) Clinical criterium - Presence or absence of incontinence, normal or abnormal condition of micturition and volume of residual urine.

(b) Cystometrogram (Fig. 10) - with particular emphasis on the presence or absence of a basic tone, the value of the neo-bladder contractions and the vesical capacity.

FIG. IX (a)

SECOND STAGE OF THE EXPERIMENT: Intestino-cystoplasty in 22 Dogs

A. Four techniques utilized after subtotal cystectomy ..... Leaving Intact Trigone and Ureters.

1. COLOCYSTOPLASTY IN 9 DOGS

Isolated segment of colon
attached to its meso
vascularization left intact
from the descending colon as high as possible
14 cms long
proximal end of the loop closed

2. ILEO-CYSTOPLASTY IN 6 DOGS

Segment of ileum
attached to its mesentery
vascularization left intact
from the ileum - 20 cms from ileocoecal junction
18 cms. long
proximal end of the loop closed
distal end anastomosed to the trigone

3. ILEO-CYSTOPLASTY WITH REVERSED SERO-MUSCULAR ILEAL GRAFT IN 6 DOGS

Isolated segment of ileum - 40 cms long -
attached to its mesentery
opened at 1 cm. from its mesenteric border
mucosa completely stripped off at the submucosal junction
fashioned as a patch

Graft being sutured to trigone

4. ILEO-CYSTOPLASTY WITH DENUDED SERO-MUSCULAR GRAFT IN 1 DOG

Isolated segment of ileum - 40 cms long
attached to its mesentery
opened along its antemesenteric border
mucosa completely stripped off at the submucosal level
fashioned as a large rounded patch
suture of this patch to the trigone.

TYPE OF INTESTINO-CYSTOPLASTY ACCORDING TO THE FIRST STAGE

Type of neurotomy	Colic Segment ♂	Colic Segment ♀	Ileal Segment ♂	Ileal Segment ♀	Reversed ileal graft ♂	Reversed ileal graft ♀	Denuded ileal graft ♂	Denuded ileal graft ♀
Sacral neurotomy	1	2	1	2		1		
Posterior root section	3	1	1	1		2		1
Spinal cord section	2			1	1	2		

FIG. IX (b)

B. RESULTS OF INTESTINO-CYSTOPLASTY IN 11 DOGS

Two of seven months after the operation (Average of 5 months)

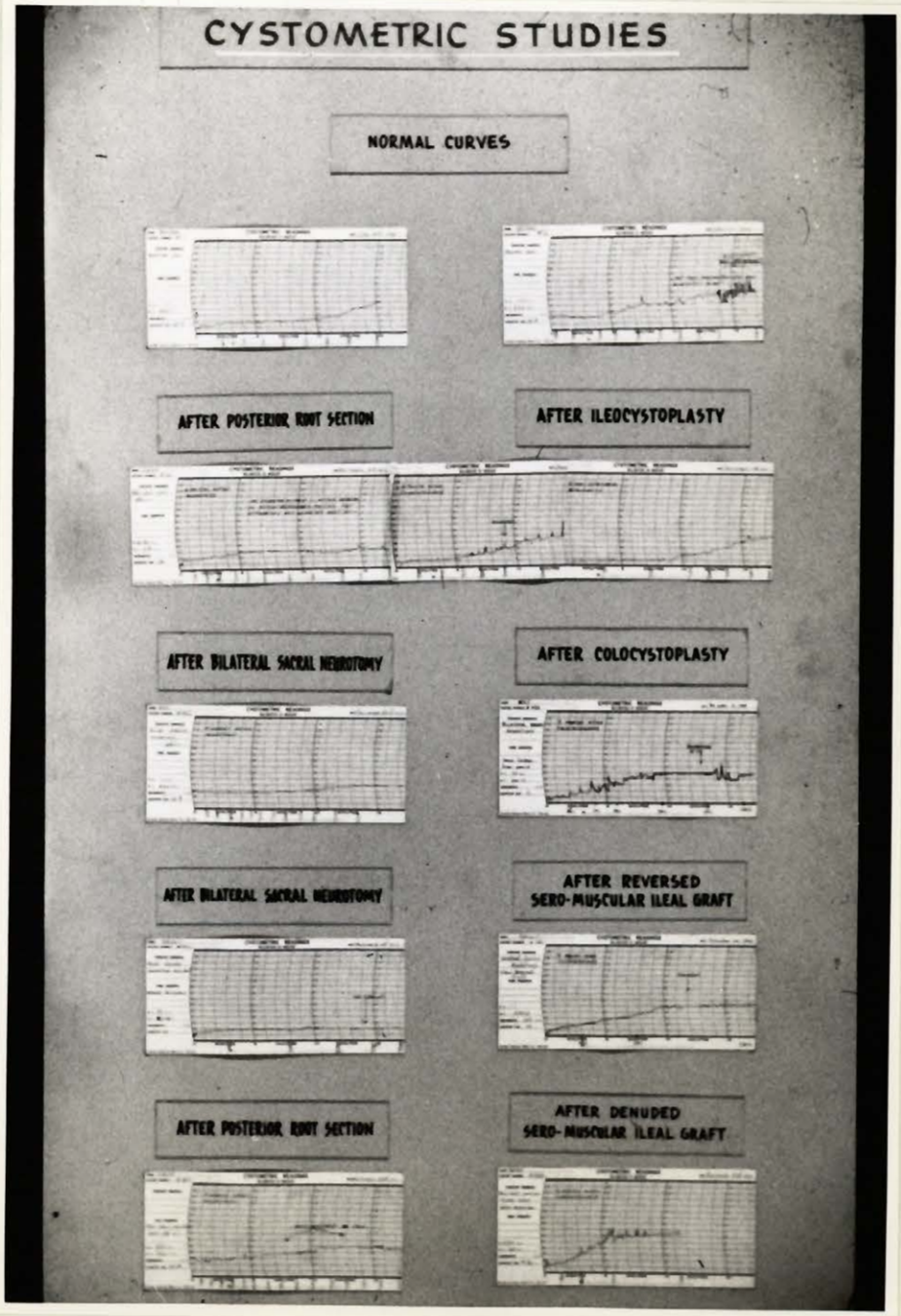
	Colo-cystoplasty	Ileo-cystoplasty	Reversed muscular graft	Denuded ileal graft
Bilateral	K-2 no complications	C. No complications	Y. Lt. Vesico Urethral Reflux	
Sacral Neurotomy	Normal Function Capacity 260 cc. Basal Tone 50 mm Hg.	Dribbling Capacity 125 cc. Basal Tone 50 mm Hg.	Normal Function Capacity 250 cc. Basal Tone 50 mm Hg.	
Posterior Root Section	G. No complications Normal Function Capacity 250 cc. Basal Tone 50 mm Hg.	Bt 1. Vesico Urethral Reflux Dribbling Capacity 60 cc. Basal Tone 60 mm Hg.	Bt. 1 Vesico Urethral Reflux Normal function Capacity 100 cc. Basal Tone 35 mm Hg.	N^2 No complications Normal Function Capacity 180 cc. Basal Tone 60 mm Hg.
			L2 No complications Normal Function Capacity 310 cc. Basal Tone 50 mm Hg.	
Spinal Cord Section	R2 No complications Normal Function Capacity 175 cc. Basal Tone 54 mm Hg.		X No complications Dribbling Capacity 190 cc. Basal Tone 48 mm Hg.	
	L. No complications Normal Function Capacity 175 cc. Basal Tone 50 mm Hg.			
Post-operative mortality (Early & Late)	5 out of 9	3 out of 6	3 out of 6	NIL

1) Dribbling on Urination)
Vesico-Urethral Reflux (Where only seen in Ileo-cystoplasty and reversed sero-muscular graft.
Shrinkage of the Graft)

2) None of these grafts developed significant residual urine volume.

3) The basal tone was higher than normal (between 40-60 mm. of mercury) This tone was the same regardless of segment of intestine or technique used.

FIG. X


CYSTOMETRIC STUDIES
NORMAL CURVES
AFTER POSTERIOR ROOT SECTION
AFTER ILEOCYSTOPLASTY
AFTER BILATERAL SACRAL NEUROTOMY
AFTER COLOCYSTOPLASTY
AFTER BILATERAL SACRAL NEUROTOMY
AFTER REVERSED SERO-MUSCULAR ILEAL GRAFT
AFTER POSTERIOR ROOT SECTION
AFTER DENUDED SERO-MUSCULAR ILEAL GRAFT

(c) Radiological criterium - intravenous pyelogram and retrograde cystogram (Fig. 11).

(d) Anatomical criterium - Particularly the characteristics of the neo-vesical epithelium after resection of the intestinal mucosa.

(a) The results are summarized in Fig. Nº 9. Very good results were obtained in 6 dogs.

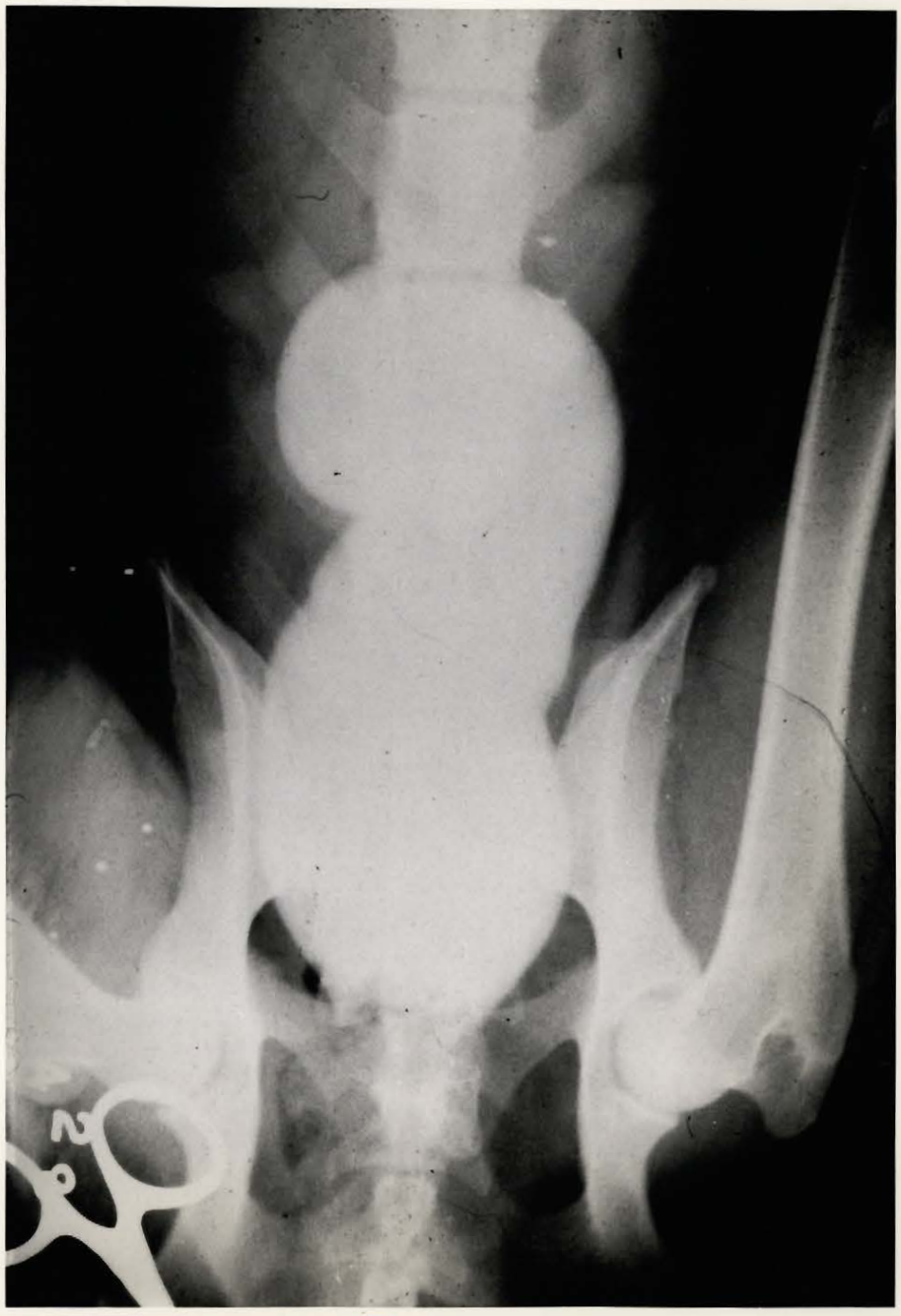
There was a certain degree of incontinence in the case of 3 dogs. Each of these 3 dogs had had different types of neurotomy.

Two of the incontinent dogs had a simple ileo-cystoplasty, while the bladder of the third dog was replaced by an inverted sero-muscular graft such as in the third technique described.

A vesico urethral reflux was observed in 3 other dogs. Of the latter group, two had an ileo-cystoplasty with an inverted sero-muscular graft and the third a simple ileo-cystoplasty.

It is to be noted that the external sphincter was atonic in the cases where incontinence had developed but, on the other hand, among the dogs who had shown good results many had an atonic sphincter. This

FIG. XI (a)



Colocystoplasty - Cystogram

FIG. XI (b)

Ileocystoplasty-Cystogram Stenosis of the anastomoses

FIG. XI (c)

Reversed sero-muscular ileal graft-cystogram
Vesico-urethral reflux

FIG. XI (d)

Denuded sero-muscular ileal-graft-cystogram

tends to prove that the intestino-cystoplasty technique employed was responsible for this complication, rather than the pre-existing condition of the external sphincter.

Paradoxically, none of the dogs who had a colo-cystoplasty developed any urinary incontinence whereas it is an established fact that the colic bladder has a higher tone than the ileal bladder.

It remains however that 8 of these neurotomized dogs showed a normal mictutition after cystoplasty; their external sphincter being either atonic or normal.

(b) It was found that the lowest vesical capacity was obtained after ileo-cystoplasty (60 cc and 125 cc), and after inverted sero-muscular graft (100 cc). Vesical capacity was satisfactory in all the other cases.

(c) In all cases the residual urine did not exceed 20 cc.

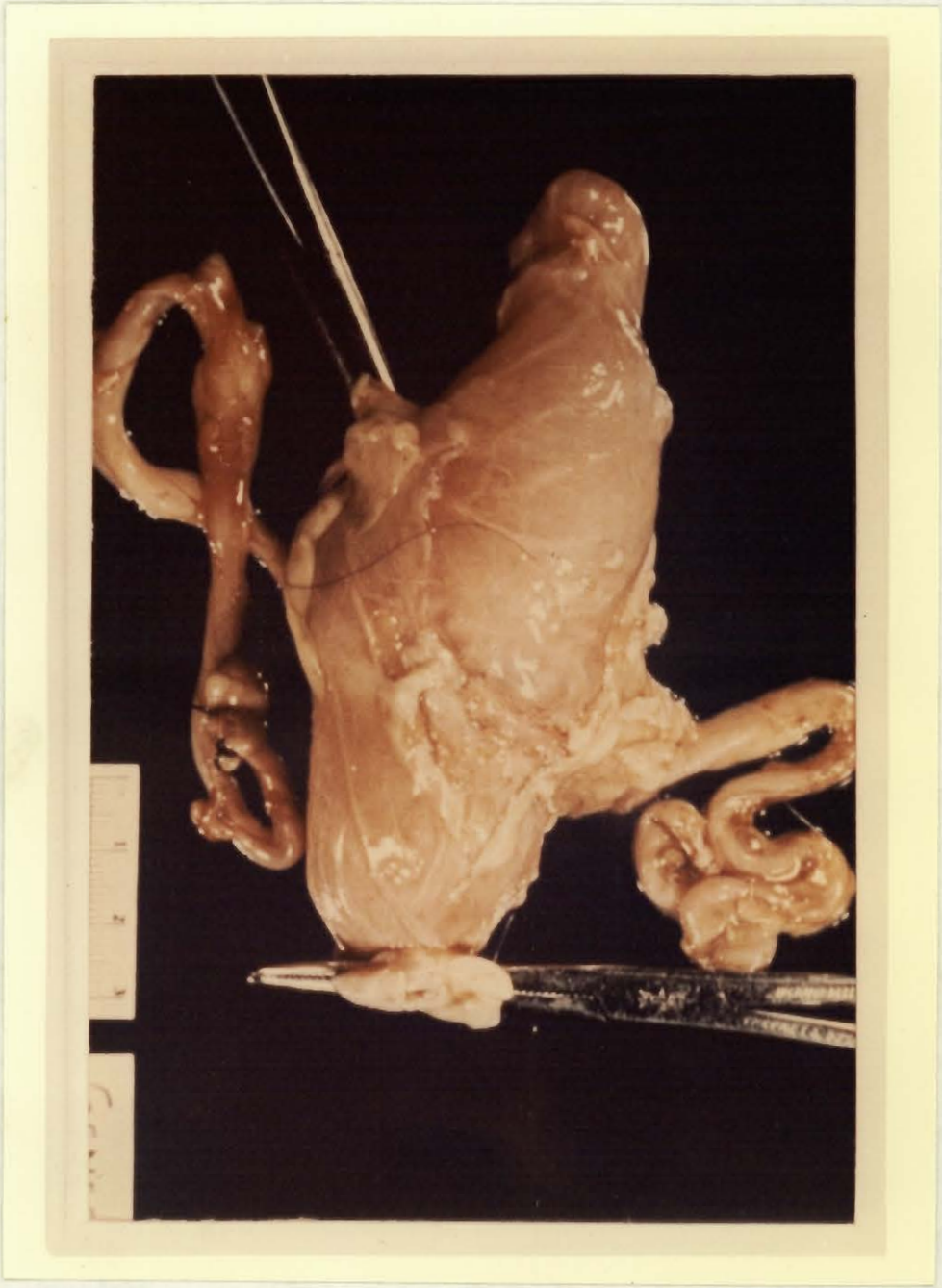
(d) From a pathological point of view, it was impossible to find evidence even 6 months later of the development of transitional cell epithelium, inside the denuded graft,

after stripping of the intestinal mucosa practiced in last two techniques. Neither were areas of fibrous tissue or islets of intestinal mucosa found on the slides. Fig. 12 illustrates the different types of pathological specimens according to the technique employed.

C. DISCUSSION

1. It appears that these findings represent a step forward in the application of the intestino-cystoplasty in the treatment of neurogenic bladders, and this is the extent to which the animal experiment can be applied to man. The former, in fact, leads us to believe that the intestino-cystoplasty can be successfully applied when the detrusor alone is affected, such as in the posterior root lesions as well as in the peripherical neuron lesions when an autonomous bladder is accompanied by flaccidity of the external sphincter. One question arises however: How can we expect vesical continence when the two sphincterian systems are paralyzed? In other words, will the experiment on man confirm the findings of that on animal? The tone of the intestinal reservoir is much lower than the detrusor's, and less resistance of the sphincterian system is required to assure the continence of the new bladder. Is the urethral resistance a significant factor for urinary continence?

FIG. XII (a)

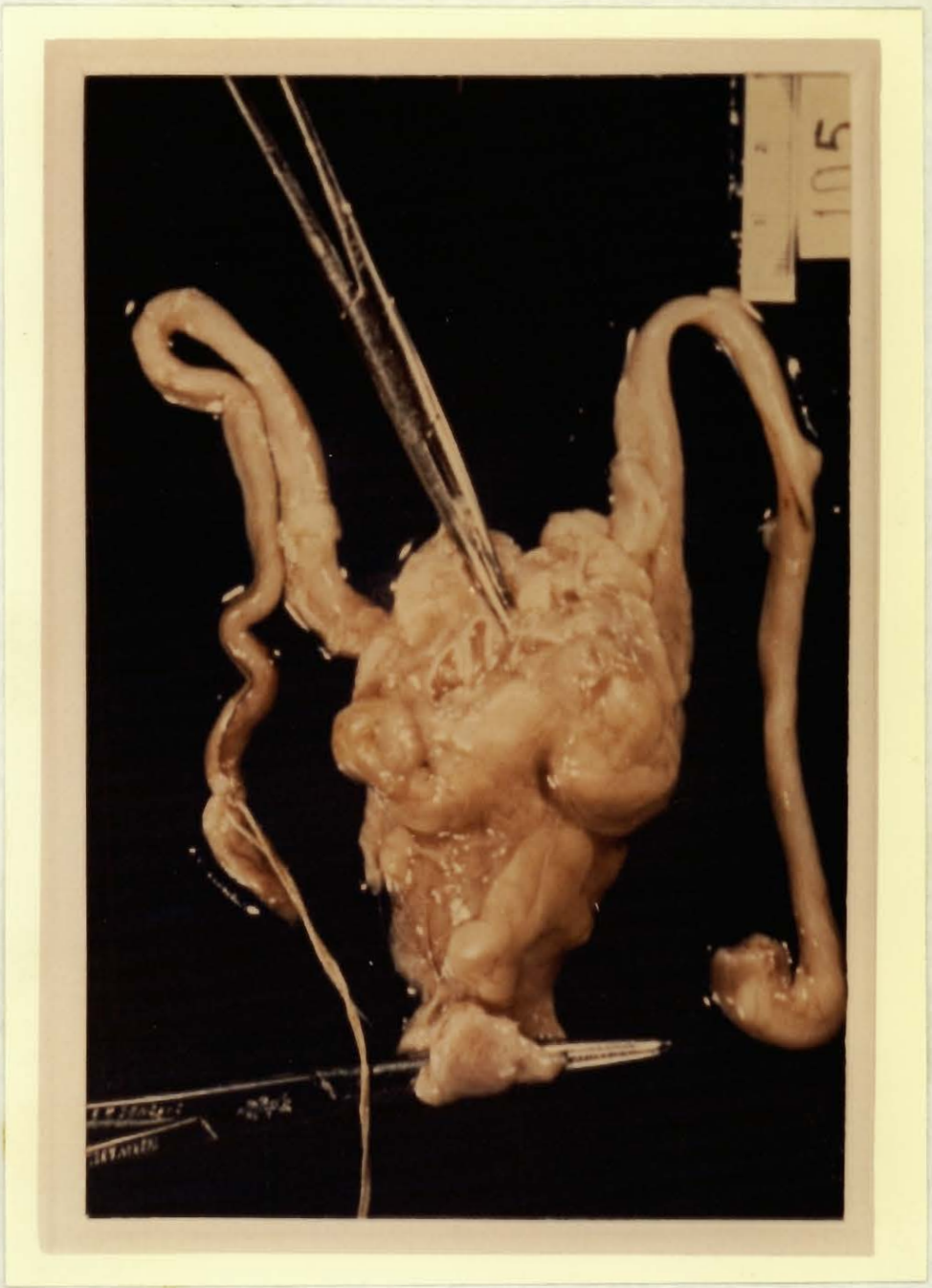


Colo-cystoplasty

FIG. XII (b)

Ileo-cystoplasty

FIG. XII (c)



Reversed Sero-muscular ileal graft

FIG. XII (d)

Denuded Sero-muscular Graft

It is against the laws of hydraulics that in the absence of sphincter activity, the length and diameter of the urethral canal alone could produce continence, even though the new bladder has a lower tone than a normal detrusor. In spite of this, will the operation give better results in male than in female patients? This difference has not been evidenced in dogs. Among the three cases who developed urinary incontinence, one was a male and two were female. It seems that a more moderate statement would be closer to the truth. In the absence of vesical neck, some tone has to be present in the external sphincter in order to provide urinary continence. It is unfortunately still impossible to measure accurately the minimum level of tone required.

Another problem is yet to be solved. How much intra-abdominal pressure is necessary to effect satisfactory evacuation of the intestinal bladder? It appears to us that intra-abdominal pressure has a very important role in such cases and that a paralyzed abdominal musculature is a contraindication to the intestino-cystoplasty in paraplegics.

Finally, it was impossible in this experiment to produce a central neuron lesion with spasticity of the internal pudendal territory.

It seems to be reasonable to assume, however, that an intestino-cystoplasty practiced in these conditions would be bound to fail due to the spasticity of the external sphincter.

Would a secondary internal pudendal neurotomy remedy this? It seems that the intestino-cystoplasty in the case of a high lesion is not too promising in view of the previously discussed argument: the generally associated paralysis of the abdominal musculature makes it very doubtful that satisfactory urinary drainage can be established.

(a) Among the different means of rehabilitating the bladder, as practiced at present, what are the indications for intestino-cystoplasty?

i) When an alcoholisation or an internal pudendal neurotomy or a sacral neurotomy or a section of the nervi erigentes is contraindicated and particularly so in the presence of any sexual function.

ii) Otherwise, following a long period of vesical drainage when the bladder is infected, fibrosed or of small capacity, and these conditions are irreversible, the replacement of the detrusor appears to be the only reasonable solution.

(b) There are some cases where the cystoplasty appears to be contraindicated.

i) First of all, it is evident that for certain paraplegics there is no other possibility but the vesical drainage, as they are unable to control their needs. This is the case for all the quadriplegics and many women confined to bed or wheel chair for whom the use of a ben pan is impossible.

ii) Furthermore the mental condition of the patient has to be good enough to permit the possibility of vesical rehabilitation.

iii) It seems that this operation has little chance of success when the patient is unable to develop the necessary intra-abdominal pressure.

2. The technique remains to be discussed. In this animal experiment the colo-cystoplasty and the denuded sero-muscular ileal graft have given better results. The choice lies between these two techniques in most instances, although the latter technique deserves more attention. In our opinion, the colo-cystoplasty is the prefered choice when normal activity of the sigmoid colon

has been verified by fluoroscopy after barium enema. Three arguments are opposed to the second technique. First of all, it is a much longer procedure; secondly, the insufficient lenght of the mesenteric pedicle may present a drawback in many cases; thirdly, we have been unable to find evidence of re-epithelisation of the mucosa-free graft by the transitional epithelium from the trigone, thus reducing considerably the practical value of this procedure in comparison with the colo-cystoplasty.

Whereas this technique seems preferable to any other type of ileo-cystoplasty it might be justified only when the colo-cystoplasty is contraindicated due to colic atony.

CHAPTER V

CONCLUSION

44 dogs were submitted to a neurotomy in order to create types of neurogenic bladders most frequently encountered in clinic. 22 of these dogs had an intestino-cystoplasty according to four different techniques. The clinical, radiological, cystometrical and anatomical results were evaluated in 11 of these dogs, about 5 months after cystoplasty. The results can be summarized as follows :

1. 7 dogs presented normal micturition and no complication.

2. Urinary incontinence, vesico-uretEral reflux and small bladder capacity developed only in the cases where a simple ileo-cystoplasty or a reversed sero-muscular ileal graft had been used.

3. Colo-cystoplasty and denuded sero-muscular ileal graft produced the best results.

4. The re-epithelisation of the ileal graft where mucosa had been removed dit not occur from the intact trigone.

Some practical conclusions can be drawn from these results concerning the indications for an intestino-cystoplasty in the course of neurogenic urinary diseases.

This operation can in fact be recommended :

1. In case of atonic bladder due to posterior horns or roots lesions.

2. In autonomous bladders due to a peripheral neuron lesion -when the tone of the perineal floor is at least partially preserved- with probably more chance of success in male than in female patients, whose urethral resistance is higher.

This operation is preferable to neuro-surgical procedures when vesical rehabilitation is considered.

1. When neurotomy is contraindicated in the presence satisfactory sexual function.

2. When the detrusor is irreversibly fibrous and there is no possibility of recovery even after a neurotomy.

Finally, this operation is contraindicated :

1. when the mental state and functional condition of the patient does not permit anything but an indwelling catheter or some type of urinary diversion.

2. When there is a lesion of the central neuron with spasticity of the internal pudendal region

and paralysis of the abdominal musculature.

3. In cases of rapidly progressive neurological lesions.

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