ACTA ORTHOPAEDICA SCANDINAVICA
SUPPLEMENTUM NO. 142

From the Department of Orthopaedic Surgery, University Hospital, Umeå (Head: Prof. J.A. Sevastikoglou, M.D.) and the Hospital of Orthopaedic Surgery, Härnösand, Sweden (former Head: Dr. Nils Lindström, M.D., M.D.Hon.).

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A COMPUTER-AIDED ANALYSIS OF 2,504 OPERATIONS

BY

ERIK V. SPANGFORT

MUNKSGAARD
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AKADEMISK AVHANDLING
SOM FÖR VINNANDE AV MEDICINE DOKTORSGRADEN MED VEDERBÖRLIGT TILLSTÅND AV MEDICINSKA FAKULTETEN VID UNIVERSITETET I UMEÅ KOMMER ATT OFFENTLIGEN FÖRSVARAS I AULAN, SJUKSKÖTERSKESKOLAN, UMEÅ, LÖRDAGEN DEN 13 MAJ 1972, KL. 09.00.

BY

ERIK V. SPANGFORT

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March 1972
ERIK SPANGFORT

CHAPTER I
INTRODUCTION

Surgical treatment of lumbar disc herniations dates back to September 1933, when MIXTER & BARR read their historical paper »Rupture of the Intervertebral Disc with Involvement of the Spinal Canal» to the New England Surgical Society at Boston. The conception of disc herniation as a common cause of low back pain and sciatica was quickly accepted, and within a decade the lumbar disc operation was a common operation in many countries.

Surgical removal of the offending disc herniation offered a simple and efficient solution to the frustrating problem of relieving patients with severe sciatic pain, and after almost forty years of extensive use, the lumbar disc operation maintains a well-established position as a reasonably safe procedure with a majority of satisfactory results. The operative technique no longer presents major problems, vast clinical experience has been accumulated, and an abundance of literature covers all aspects of the subject.

In spite of this, an apparently inevitable rate of failures is still a matter of considerable concern, and several important clinical problems remain unsettled - in particular regarding the validity of the preoperative diagnosis, the proper selection of patients for surgical treatment, and a reliable, preoperative identification of »poor-risk»-cases.

One reason for this state of affairs is, no doubt, the fact that the lumbar disc herniation is but one element in Man' s complex low back problem, and the outcome of the single disc operation is governed by a large number of multivariate factors, some of which may still be quite unknown.

The limited capacity of manual data processing has, so far, been an obstacle to further advance towards a better understanding of these complicated clinical correlations, and the rapid development of automated data processing, therefore, seems to create an opportunity for renewed investigation of unsettled clinical problems in this field.

The purpose of this report is to present selected parts of the results achieved by a complete computer-aided analysis of all reliable information contained in the medical records of 2,504 consecutive operations for lumbar disc herniations.

An attempt to utilize the vast amount of clinical experience accumulated during decades of surgical practice and, as far as possible standardize this information for future use, was conceived as a pertinent task before launching large-scale prospective projects with modern methods of data processing.

In order to study the main trends in the development of disc surgery during the last forty years and establish a reference between the current pattern in this field and the analysed series of 2,504 operations, a large number of previous reports on the lumbar disc operation were compiled and systematically analysed with respect to all variables classified in the original material.

COMPOSITION OF THE MATERIAL

The material consists of all surgical operations for suspected lumbar disc herniations performed at the Orthopaedic Hospital in Härnösand during the years 1951-66 and at the Department of Orthopaedic Surgery in Umeå during the years 1959-65.

Operations in which the main indication for surgical treatment was spondylolisthesis or chronic low back pain are not included in the material.

For practical reasons the total material was divide into three sections:

Series H.I: Härnösand	1951-60	1,122 operations
Series H.II: Härnösand	1961-66	947 operations
Series Umeå	1959-65	435 operations

Certain clinical variables were studied in particular detail in one or two of these series.

With few exceptions, severe pain was the main indication for operation in all patients, and it would be desirable to include the characteristics of the pain in the analysis, but the medical records were not detailed enough to allow a retrospective classification on this point.

THE DEPARTMENTS

The Orthopaedic Hospital in Härnösand was established in 1931 as the Institute for the Crippled in Northern Sweden and served approximately 1,000 000 people. Since 1957 the large area originally assigned to this hospital has been reduced by the creation of several new orthopaedic centres, and the hospital now receives orthopaedic patients from a district with a population of approximately 277,000.

The Orthopaedic Department in Umeå was opened in 1959 as part of the University Hospital and receives patients mainly from a district with 234,000 inhabitants. As part of a teaching hospital the department will, however, admit some cases from local hospitals in other districts as well.

OPERATIVE TECHNIQUE

The standard surgical procedure at these departments is a unilateral, interlaminar exposure of the intervertebral space *a.m.* LOVE (1939) with the patient placed prone on an adjustable frame to flatten the lumbar curve. A piece of bone is often removed from the lamina together with the ligamentum flavum, and if necessary for a satisfactory exploration, the exposure is readily extended with complete hemilaminectomy and more or less extensive facetectomy.

More than one level is explored only when required by the clinical or the radiographic picture, or by unsatisfactory findings at the primary level.

When bilateral exposure is required, which was seldom the case in the present material, the unilateral approach is repeated at the opposite side without complete laminectomy.

Besides removing all loose fragments of disc tissue, it is the practice to excise degenerated tissue from the interior of the intervertebral space without attempting to remove the total disc.

In general, the »combined operation» - *i.e.* combined disc operation and spinal fusion - is not recommended at these departments. However, in a small group of 22 patients with disabling low back disorders, the disc operation was combined with posterior spinal fusion; these cases are included in the material.

THE SURGEONS

The operations studied in the present analysis were performed by a total of 39 orthopaedic surgeons.

The highest number of operations performed by a single surgeon was 423 and three surgeons participate with only one operation each.

ANAESTHESIA

A combined spinal and local anaesthesia was used in 1,956 cases or 78.1 per cent of the operations. Spinal anaesthesia alone was used in 12.7 per cent, local anaesthesia in 8.1 per cent, and general anaesthesia in 1.1 per cent of the operations.

There was no mortality associated with anaesthesia in these series.

Postoperative wound infection of moderate or severe degree occurred in 94 cases or 3.8 per cent of all operations. When correlated to the type of anaesthesia, this incidence was 1.9 per cent (6/317) after spinal anaesthesia, 5.9 per cent (12/203) after local anaesthesia, and 3.9 per cent (76/1956) after combined spinal and local anaesthesia. One mild wound infection occurred after 26 operations in general anaesthesia, but none of moderate or severe degree.

These subgroups are not strictly comparable as local anaesthesia alone was used mainly during the early part of the period 1951-66 and general anaesthesia particularly the last years. However, the study indicates that the incidence of postoperative wound infection tends to increase if the anaesthetic procedure involves preoperative injections in the surgical field. Moreover, the degree of infection seems to be more severe in these subgroups.

A certain risk of neurological complications after spinal anaesthesia has been established by many investigations. Damage to the nerve roots was estimated by THORSÉN (1947) to occur in not less than 0.5 per cent of 2,493 cases of spinal anaesthesia and by DRIPPS & VANDAM (1954) in 0.7 per cent of 10,098 cases.

In the present material contralateral paresis of the foot was observed in 0.6 per cent (14/2273) of the operations performed under spinal anaesthesia, while this complication was not registered after 231 operations with other types of anaesthesia. As the majority of the contralateral complications are presumably caused by the anaesthesia these observations agree with previous reports. In most of the cases recorded in this material the paresis was partial and more or less transient, which is also in agreement with previous investigations.

COLLECTION AND PROCESSING OF DATA

The medical records for the material were collected by studying the departments' register of patients admitted during the surveyed periods. As a control measure the registers of all surgical operations and myelographies performed during the period were also reviewed. All records and radiographs in question were procured from the files.

All classification and coding of information retrieved from the medical records was carried out by the author, and the acquired data transferred to manual punch-cards for preliminary study and further standardization.

In a large number of cases registered information was verified and replenished by interviews and examination of patients, inquiries to practitioners and other hospitals, and examination of radiographs.

When the comprehensive work of primary classification and standardization was completed, the material was revised in all details by a second personal reading of the medical documents and subsequently transferred to an IBM computer for automated processing.

In each case the following 54 variables were classified and coded for data processing:

Identification
Sex
Age at operation
Occupation
Department and series
Year of operation
Month of operation
Re-operations
Postoperative period of observation
Operative technique
Surgeon
Anaesthesia
Spondylolisthesis
Previous spinal injuries
Preoperative fever or infections
Secondary morbidity (other diseases)
Preoperative duration of sciatica
Preoperative duration of low back pain
Preoperative radiography
Postoperative radiography
Discography
Myelography
Lasègue's sign
The crossed Lasègue's sign
Impairment of the ankle reflex
Paresis of dorsiflexion
Impairment of the knee reflex
The cauda equina syndrome
Lateralization (side of operation)
Abnormality of the levels
Level of herniation
Multiple herniations
Degree of herniation
Volume of disc tissue removed
Other findings at operation
Operative lesions to the dura
Operative lesions to the roots
Severe hemorrhage during the operation
Other surgical complications
Postoperative paresis (as surgical complication)
Postoperative wound infection
Postoperative discitis
Postoperative spondylitis
Postoperative administration of antibiotica

The Zanoli-Vecchi syndrome
Postoperative thrombo-embolism
Mortality
Other postoperative complications
Preoperative erythrocyte sedimentation-rate
Postoperative erythrocyte sedimentation-rate
Type of thermometry
Postoperative fever reaction
Relief of sciatica
Persistent low back pain

STATISTICS

The analysis is based on extensive stratification of the material by combination of two or more variables followed by calculation of frequencies and percentage distribution.

The study of age, time, and volume includes calculation of arithmetic mean, median, and variance.

The application of brackets to figures in the tables indicates percentage calculation based on 10 or less cases. The corresponding part of a curve in the graphs is indicated by dotted line.

The statistical significance of differencies in binomial and multinomial distributions is examined by the chi-square (X^2) test. The test value, significance level, and degrees of freedom (df) are reported in the text.

The significance level (p), *i.e.* the probability of rejecting the null hypothesis when it is true, is evaluated conventionally as follows:

$p > 0.05$:	not significant	
$0.01 < p < 0.05$:	almost significant	(*)
$0.001 < p < 0.01$:	significant	(**)
$p < 0.001$:	highly significant	(***)

The significance of the difference between two values of mean age is examined by Student's t-test. Comparisons between more than two mean ages are performed by analysis of variance and Scheffé's method for multiple comparisons (SCHEFFÉ, 1967).

For ethical and practical reasons it is often impossible to ensure randomness of sampling in clinical investigations of the present type. Where the above-mentioned tests are applied, the present series are assumed to fulfil the condition of randomness, but this assumption is based on judgment and not accessible to strict production of evidence. Conclusions drawn from the tests are, therefore, subject to acceptance of this assumption.

DEFINITIONS AND TERMINOLOGY

The levels: In this report the intervertebral discs are identified by the numbers of the adjacent vertebra, *i.e.* the first lumbar disc as the disc L1-L2, the second as L2-L3, *etc.*

Partial transitional features at the lumbo-sacral level were disregarded in classification of the levels. In the small group of 17 patients with complete sacralization or lumbarization, the abnormal levels were designated according to the number of the cranial vertebra, *i.e.* the level L4-S1 as »L4-L5» and the level L5-L6 as »L5-S1».

Four herniations at the level L6-S1, which would call for a separate class according to this simplification, were classified as »L5-S1» herniations.

High lumbar herniations: this name is applied to herniations at the levels L1-L2, L2-L3, and L3-L4.

The degree of herniation: the term refers to the following descriptive classification:

Complete herniation (*syn.* complete prolapse, ruptured disc, extruded disc, herniated disc, sequestrum): a herniation characterized by spontaneous rupture of the posterior longitudinal ligament and extrusion of sequestrated disc tissue.

Incomplete herniation (*syn.* incomplete prolapse, protrusion, ruptured contained disc, capsule-covered herniation, herniating disc, dissecting protrusion, nodule): a well defined, circumscribed herniation, clearly protruding beyond normal anatomical limits without rupture of the posterior longitudinal ligament.

Bulging disc (*syn.* protruding disc, generalized nuclear bulging, inspissated disc, soft disc): the lesion is characterized by a generalized bulge of the disc, protruding beyond anatomical limits and presumably large enough to cause mechanical pressure on the adjacent nerve root. This pathological condition is not considered a ***true herniation.***

No herniation, negative operation, negative exploration: these terms are used in the limited sense that no part of the disc is protruding beyond normal anatomical limits. Other pathological changes in the consistency, structure, and surface of the discs are disregarded in this classification.

Positive operation: this subgroup contains complete herniations, incomplete herniations, and bulging discs. The term does not refer to other pathological changes in the discs or the surrounding structures.

Multiple herniations: the term is used to indicate positive findings at more than one level during the same operation.***Bilateral herniations*** at the same level are not comprised in this group. The term ***true multiple herniations*** indicates a combination of complete and incomplete herniations, but is not applied if a bulging disc is part of the combination.

Sciatica and ***sciatic pain:*** these terms are used synonymously to indicate pain radiating along the course of the sciatic nerve.

Persistent low back pain: was defined for this study as a condition with a considerable degree of backache or low back pain, constant or intermittent, persisting at least one year after the disc operation.

Lasègue's sign: the term is used synonymously with »the straight-leg raising test» (LAZAREVIĆ 1880,1884).

The crossed Lasègue's sign (*syn.* the well-leg raising test, Fajersztajn's sign, Radzikowski's sign, Bechterew's sign, the crossed-sciatic phenomenon): this term indicates radiating pain of sciatic type on the affected side by straight-leg raising of the opposite leg (FAJERSZTAJN, 1901).

The term ***contralateral Lasègue's sign*** refers to Lasègue's sign in the leg opposite to the disc lesion.

Postoperative wound infections were classified as follows:

Mild infection: local inflammation without discharge or generalized wound disease. The group contains hematomas without signs of inflammation, stitch infections, and inflammatory reactions in the margins of the wound. The complication caused no delay in the patient's discharge from hospital.

Moderate infection: wound infection with a discharge and delayed healing. A moderate degree of generalized wound disease was accepted in this group.

Severe infection: wound infection with a purulent discharge and generalized wound disease. The complication usually caused a delay in the patient's discharge from hospital.

The terms ***significance*** and ***significant*** are used in this text only in the statistical sense of the words.

CHAPTER II

THE MATERIAL

NUMBER OF OPERATIONS

The total number of operations is specified by sex, series, and year of operation in Table 1.

Table 1. The total number of operations per year by sex and series (Frequencies and percentage distribution)

Series	Year of operation	Total number of operations				
		Females		Males		Both sexes
		no.	%	no.	%	no.
H.I	1951	5	16.1	26	83.9	31
	1952	7	18.4	31	81.6	38
	1953	10	32.3	21	67.7	31
	1954	17	27.0	46	73.0	63
	1955	20	18.7	87	81.3	107
	1956	36	29.0	88	71.0	124
	1957	49	30.4	112	69.6	161
	1958	56	29.9	131	70.1	187
	1959	55	30.6	125	69.4	180
	1960	51	25.5	149	74.5	200
	Total:	306	27.3	816	72.7	1 122
H.II	1961	61	32.3	128	67.7	189
	1962	58	32.6	120	67.4	178
	1963	41	28.3	104	71.7	145
	1964	52	36.6	90	63.4	142
	1965	47	30.7	106	69.3	153
	1966	56	40.0	84	60.0	140
	Total:	315	33.3	632	66.7	947
Umeå	1959	4	12.5	28	87.5	32
	1960	21	30.4	48	69.6	69
	1961	25	31.6	54	68.4	79
	1962	24	31.6	52	68.4	76
	1963	16	21.3	59	78.7	75
	1964	22	33.8	43	66.2	65
	1965	8	20.5	31	79.5	39
	Total:	120	27.6	315	72.4	435
All operations:		741	29.6	1 763	70.4	2 504

The material consists of 2,504 operations performed on 2,377 patients. The total number of operations includes 122 or 4.9 per cent 2nd operations and five or 0.2 per cent 3rd operations.

Some patients had been operated on earlier at other hospitals or in Härnösand before 1951. Only 90.7 per cent of the operations are, therefore, true 1st operations; 8.3 per cent are true 2nd operations, and 0.8 per cent true 3rd operations. Two patients had four disc operations, but the first two or three of these were performed at other hospitals.

Some of the patients in this material have been operated on after 1966. These reoperations are disregarded in the analysis.

SEX DISTRIBUTION

Previous reports

In a survey of 52 previous reports with a total of 16,412 lumbar disc operations, 33.7 per cent of the patients are women and 66.3 per cent are men (Appendix table 1). There are no exceptions from the rule of a male preponderance in these reports, and the average sex ratio 1:2 has changed little during the last three decades.

This report

In the present material the total sex distribution is 29.6 per cent women and 70.4 per cent men (Table 1). During the 16 years surveyed in Härnösand the proportion of women shows a rather constant trend to increase, but in series H.II (1961-66) the average sex distribution - 33.3 per cent women and 66.7 per cent men - is very close to the total average in previous reports.

When the sex distribution in positive operations is correlated to age at operation (Fig. 1), the male preponderance seems to be most pronounced in the age groups 20-24 and 60-64 years, but the difference is not significant ($X^2=9.370$, df=5)

AGE AT OPERATION

Previous reports

The mean age at operation in 30 previous reports with a total of 9,082 operations was 39.2 years (App.table 2). When these reports are summarized by decennia, the mean age at operation is increasing from 38.3 to 40.4 years during the last 30 years.

The sex difference in mean age at operation was specified in 10 reports with a total of 5,530 operations. In all of them the women were

Fig. 1. The rate of women in positive operations by age at operation in the total material. Dotted line indicates percentage calculation based on 10 or less cases.

younger than the men, and the total mean difference was approximately one year. There are very few exceptions from this pattern in previous reports.

This report

The mean age at operation by sex in all operations and in various subgroups is specified in Table 2.

The range of age at operation in this material is 15-74 years. The total mean age at operation was 40.8 years. In women it was 41.0 years and in men 40.7 years. This difference is not significant ($p > 0.05$).

Fig. 2 shows the mean age at operation during the 16 years surveyed in Härnösand. The mean age is increasing from approximately 38 to 44 years during this period, and the trend appears to be rather constant without notable sex difference.

The percentage distribution in age groups is shown in Fig. 3. The sex difference in distribution is not significant ($X^2 = 10.960$, df=5).

The age at operation and the distribution in age groups in these series comply with previous reports, except for a number of Japanese publications in which the mean age at operation is considerably lower.

Table 2. The mean age at operation by sex in all operations and in various subgroups

Group	Mean age at operation					
	Females		Males		Both sexes	
	no.	years	no.	years	no.	years
All operations	741	41.0	1 763	40.7	2 504	40.8
Positive operations	642	41.0	1 515	40.1	2 157	40.4
Degree of herniation						
Complete herniation	240	42.4	598	41.0	838	41.4
Incomplete herniation	339	40.0	765	39.3	1 104	39.5
Bulging disc	63	40.1	152	41.0	215	40.7
No herniation	99	41.3	248	44.1	347	43.3
Level of herniation						
L3 - L4	7	(39.9)	33	46.9	40	45.6
L4 - L5	292	42.0	731	41.9	1 023	41.9
L5 - S1	341	40.0	748	38.1	1 089	38.7

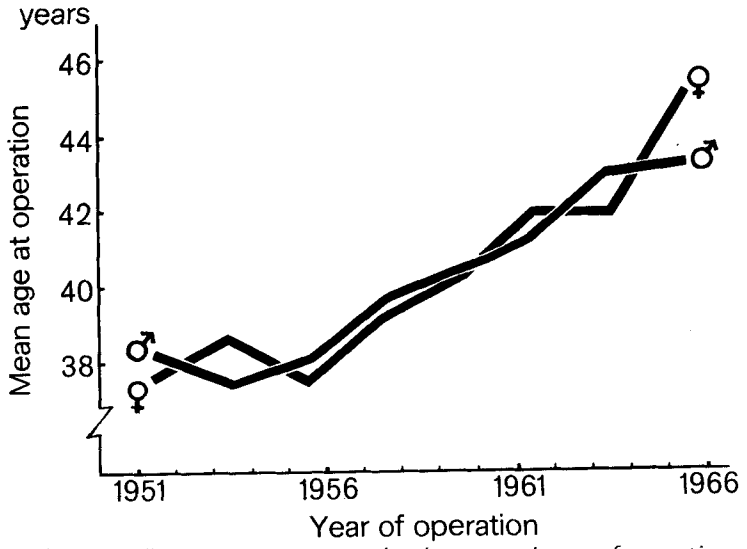

Fig. 2. The mean age at operation by sex and year of operation (Härnösand 1951-66).

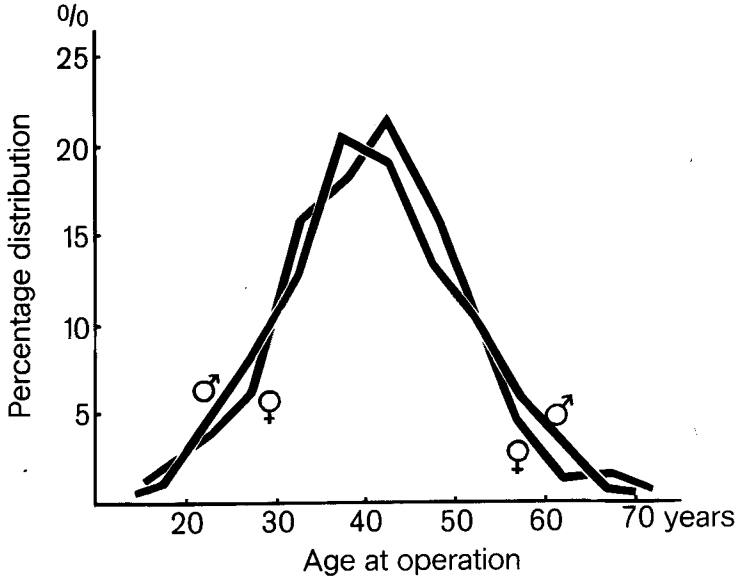

Fig. 3. The distribution in age groups by sex in the total material.

PERIOD OF OBSERVATION

The present investigation was based on available data and, in general, the information in the medical documents was accepted without further follow-up examinations of the patients. Consequently, the analysis depicts the clinical situation as it was recorded and accepted in the daily routine at the orthopaedic departments. A certain rate of short observation periods was expected as a necessary disadvantage by this method of investigation.

The postoperative observation periods are specified by sex and series in Table 3.

In 3.0 per cent of all operations information on the postoperative course was available for a period of less than 15 days after the operation, in 17.2 per cent the observation period was between 15 and 60 days, and in 79.8 per cent more than 60 days.

Most patients with a postoperative observation period between 15 and 60 days were examined at least five weeks after the operation.

With few exceptions, the patients with an observation period less than 60 days were excused from further check-up on the condition that

Table 3. The period of postoperative observation by sex and series (Frequencies and percentage distribution)

Series	Total number of operations	Period of postoperative observation								
		< 15 days			15-60 days			> 60 days		
		F no.	M no.	F+M no.	F no.	M no.	F+M no.	F no.	M no.	F+M no.
H.I	1 122	7	37	44	68	138	206	231	641	872
H.II	947	0	3	3	41	96	137	274	533	807
Umeå	435	4	24	28	21	67	88	95	224	319
Total:	2 504	11	64	75	130	301	431	600	1 398	1 998
Percentage distribution:		1.5	3.6	3.0	17.5	17.1	17.2	81.0	79.3	79.8

the postoperative course, at that time, was uncomplicated and all pain completely relieved.

The mean rate of complete relief of sciatica was 95.0 per cent in patients followed for less than 15 days, 91.6 per cent in patients followed from 15 to 60 days, and 73.1 per cent in patients followed for more than 60 days. The corresponding rates of unsatisfactory relief of sciatica, *i.e.* the subgroups »no relief» and »poor» considered together, were 0.0 per cent, 1.2 per cent, and 6.6 per cent.

PREOPERATIVE DURATION OF SYMPTOMS

Previous reports

In a survey of 15 previous reports with a total of 1,386 operations, the mean duration of »preoperative symptoms» was 3.8 years, ranging from 2.3 to 5.5 years in the single reports (App.table 3). A distinction between the duration of sciatic pain and low back pain was seldom found in previous reports.

This report

In this study the preoperative duration of symptoms, as counted from the first onset, was analysed in the 1.122 operations of series H.I. Sciatic pain and low back pain were studied separately, and the occurrence of bilateral sciatica was disregarded.

Five patients did not complain of sciatic pain before the

operation. In the remaining 1,117 cases the mean duration of sciatica was 3.3 years. The group contained 306 women with a mean duration of 3.0 years, and 811 men with a mean duration of 3.4 years.

When the preoperative duration of sciatica was correlated to occupation, 95 forest workers reported a mean duration of 2.9 years, 44 intellectuals a mean duration of 3.4 years, and 93 farmers a mean duration of 4.3 years. Also, the mean duration was increasing with age at operation from 1.7 years in patients under 30 years to 4.4 years in patients over 49 years.

A similar study of low back pain showed that eight patients complained of sciatica without low back pain before the operation. The remaining 1,114 patients reported low back pain with a mean duration of 5.6 years. In this group 305 women had a mean duration of 5.3 years, and 809 men a mean duration of 5.7 years.

By correlation to occupation, 98 forest workers as well as 44 intellectuals reported a mean duration of 5.0 years, while 93 farmers had 7.0 years.

CHAPTER III
RADIOLOGY

Plain radiographs

At these departments radiographs of the lumbar spine in two projections and the pelvis have been the minimum requirement before disc operation. Preoperative pictures were available for the analysis in 99.1 per cent of the cases, postoperative pictures in 30.0 per cent. A complete analysis of the radiological material was, however, beyond the purpose of the present study.

Preoperative discography was performed in 21 cases or 0.8 per cent of all operations.

Preoperative myelography

A total of 498 operations or 19.9 per cent of all operations were performed without preoperative myelography, usually because the clinical picture was considered typical. In this group 31.0 per cent of the herniations were located at the level L4-L5 and 69.0 per cent at the level L5-S1. The mean rate of negative explorations was 5.7 per cent in the age group 15-49 years, and then increased with high significance to 35.0 per cent in the age group 55-59 years ($X^2=16.217^{***}$, df=1).

Pneumomyelography was used in 72 cases or 2.9 per cent - two of these belonged to the series from Umeå and 70 were performed in Härnösand during the years 1951-55.

In the remaining 1,934 cases the patients were examined by lumbar myelography with water-soluble iodine contrast before the operation; 193 of these examinations were performed at other hospitals and 1,741 in Härnösand or Umeå.

In the total group of myelographies with water-soluble contrast, 75.8 per cent were described as positive, 11.5 per cent as negative, and 12.7 per cent as ambiguous.

When positive and negative myelographies in this group were correlated to the findings at operation, 82.3 per cent were true positive or true negative predictions and 17.7 per cent were false positive or false negative predictions. In 246 patients with ambiguous myelographies, the findings at operation, as classified by the degree of herniation, showed a close resemblance to the pattern in patients with negative myelographies.

Fig. 4. The incidences of false positive and false negative myelographic predictions by age at operation.

In Fig. 4 the incidences of false negative and false positive myelographies are correlated to age at operation. The incidence of false negative predictions is independent of age (X^2=1.532, df=4), while the incidence of false positive predictions is increasing insignificantly from

the age of 35 years and with high significance after 57 years (X^2=21.746***, df=4).

In Table 4 the result of myelography is correlated to the level of herniation in patients with true herniations. The rate of correct predictions is significantly higher at the level L4-L5 than at the level L5-S1 (X^2=12.678***,df=4).

Table 4. The result of myelography with water-soluble contrast correlated to level of herniation in patients with complete or incomplete herniations (Frequencies and percentage distribution)

Result of myelography	Level of herniation					
	L3-L4		L4-L5		L5-S1	
	no.	%	no.	%	no.	%
Positive (i.e.true positive)	30	83.3	663	86.6	519	79.6
Negative (i.e.false negative)	2	5.6	46	6.0	65	10.0
Ambiguous	4	11.1	57	7.4	68	10.4
	36	100.0	766	100.0	652	100.0
Operations without myelography	0		132		298	

Comments

i. Judging from this study, patients with a typical clinical syndrome before the age of 50 years may be operated on without preoperative myelography with a low risk of negative exploration. After the age of 50 the diagnostic value of the clinical syndromes apparently deteriorates rapidly.

ii. The incidence of false negative myelographies was largely independent of age, while the incidence of false positive myelographies was increasing with high significance after the age of 57 years. Thus, the myelographic examination may be assumed to maintain a high degree of diagnostic value for nearly ten years more than the general, clinical syndromes.

iii. The rate of correct myelographic predictions was found to be significantly higher at the level L4-L5 than at the level L5-S1. This observation is in agreement with many previous reports (*e.g.* FRIBERG & HULT 1950, KNUTSSON & WIBERG 1958, LEIKKONEN 1959, EDGREN *et al.* 1966).

CHAPTER IV
PREOPERATIVE NEUROLOGY

LASÈGUE'S SIGN

Previous reports

A positive Lasègue's sign - or straight-leg raising test - is generally considered the most frequent preoperative sign in patients with lumbar disc herniations. In a survey of 11 previous reports with a total of 2,433 verified herniations, the sign was positive in an average of 91,9 per cent (App.table 4).

There seems to be no previous investigations of a possible sex difference in the incidence of Lasègue's sign, but KENDALL & KENDALL (1948) found that girls are more flexible than boys, and according to ADAMS (1964) the normal range of pain-free straight-leg raising is often more than 90 degrees in women.

INMAN & SAUNDERS (1942) and FALCONER *et al.* (1948a) demonstrated that the maximum motion of the roots by straight-leg raising occurs at the fifth lumbar and upper sacral nerves, while a distal migration was not observed at the third lumbar nerve or those above.

This report

In this material the sign was registered as positive or negative in all the medical record, but the information was not always detailed enough for further grading of the positive reactions. The sign was therefore classified as »positive» or »negative» for the analysis and accepted as »positive» only if the test caused radiating pain of sciatic type. Furthermore, the sign was classified for the affected leg only and the occurrence of contralateral signs was disregarded.

Table 5 shows the incidence of patients with Lasègue's sign by sex, age, and findings at operation. In the total material the sign was positive before the operation in 95.7 per cent of the patients. In 2,157 patients with verified herniations the sign was positive in 96.8 per cent.

Women had a positive Lasègue's sign in 94.1 per cent, men in 96.4 per cent. This sex difference is significant ($X^2=6.732$ **, df=1). Also when the material was separated by degree of herniation, women had a lower incidence of the sign in all subgroups, but this difference was not significant ($X^2=1.505$, df=3). In patients with true herniations, however, the lower female incidence was still almost significant

Table 5. The incidence of patients with Lasègue's sign by sex, age, and findings at operation (Frequencies and per cent of group total)

Group		Total number of operations	Findings in patients with positive Lasègue: Positive no.	Positive %	Negative no.	Negative %	Total no.	Total %
Sex:	Females	741	613	95.5	84	84.8	697	94.1
	Males	1 763	1 475	97.4	224	90.3	1 699	96.4
Age:	15 - 19	30	27	100.0	2	(66.7)	29	96.7
	20 - 29	292	249	97.6	37	100.0	286	97.9
	30 - 39	834	731	98.4	83	91.2	814	97.6
	40 - 49	859	719	96.4	101	89.4	820	95.5
	50 - 59	396	304	95.0	65	85.5	369	93.2
	60 - 69	89	56	87.5	20	80.0	76	85.4
	70 - 74	4	2	(100.0)	0	(0.0)	2	(50.0)
Total:		2 504	2 088	96.8	308	88.8	2 396	95.7

(X^2=6.059 *, df=1). Similarly, a lower female incidence was repeated at both the low lumbar levels.

As shown in Fig. 5, the incidence of a positive Lasègue's sign was decreasing with age (X^2=48.570 ***,df=4). The negative correlation to age was repeated in both sexes, in positive and negative operations, and at both the low lumbar levels.

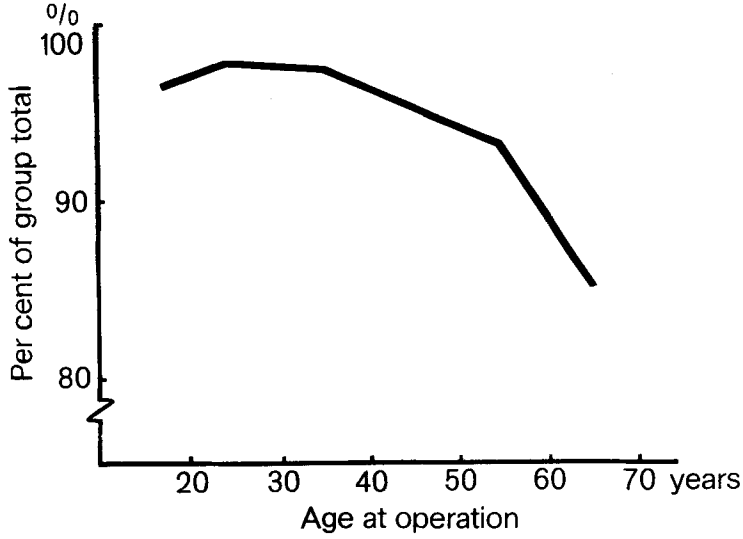

Fig. 5. The incidence of Lasègue's sign by age at operation in the total material.

By correlation to the degree of herniation, the incidence of the sign was 88.8 per cent in negative explorations, 94.0 per cent in patients with bulging discs, 96.4 per cent in incomplete herniations, and 98.1 per cent in complete herniations. This correlation is highly significant (X^2=54.905 ***, df=3).

In 1,089 patients with verified herniations at the level L5-S1, the incidence of the sign was 97.7 per cent, in 1,023 patients with herniations at the level L4-L5 it was 96.9 per cent. This difference is not significant (X^2=1.392, df=1). In patients with high lumbar herniations at the levels L1-L4, the incidence was 73.3 per cent, which is a highly significant decrease as compared with the two low levels (X^2=74.177***,df=1).

Comments

i. The present study indicates that women may be less inclined to react with a positive Lasègue than men. The sex difference was significant only when all women and all men were compared, but the lower female incidence was repeated in all subgroups and may possibly represent a true physiological sex difference in the reaction to straight-leg raising.

ii. The decrease in the incidence of the sign with age, which was highly significant and repeated in all subgroups, also seems to disclose a decrease in the physiological propensity to react positively to the test. In spite of this, the diagnostic value of the test is probably increasing with age, as the decreasing Lasègue-propensity is followed by an increased diagnostic specificity (SPANGFORT, 1971).

iii. Although the test was positive in 88.8 per cent(308/347) of the negative explorations, the incidence of the sign increased with the degree of herniation, and the correlation was highly significant.

iv. The study confirms that the incidence of Lasègue's sign is higher at the two low levels than at the high lumbar levels, and the difference is highly significant. When the two low levels are compared the difference is not significant, but it seems as if the level L5-S1 maintains a higher Lasègue-propensity with age than the level L4-L5.

THE CROSSED LASÈGUE'S SIGN

Previous reports

The mechanism of the crossed Lasègue's sign has been discussed at some length in the literature, but clinical data on the sign was found in only 9 reports with a total of 1,773 operations (App.table 5). In these reports the sign was positive in 19.1 per cent - with a notable range from 8.6 to 43.1 per cent in the single reports.

This report

In Table 6 the incidence of patients with a crossed Lasègue's sign is specified by sex, age, and findings at operation.

The sign was registered as positive before the operation in 21.6 per cent of all cases; in the rest of the medical records it was negative or not mentioned. In patients with verified herniations the incidence of the sign was 23.2 per cent.

Table 6. The incidence of patients with crossed Lasègue's sign by sex, age, and findings at operation (Frequencies and per cent of group total)

Group		Total number of operations	Findings in patients with crossed Lasègue: Positive no.	Positive %	Negative no.	Negative %	Total no.	Total %
Sex:	Females	741	131	20.4	12	12.1	143	19.3
	Males	1 763	369	24.4	29	11.7	398	22.6
Age:	15 - 19	30	17	63.0	1	(33.3)	18	60.0
	20 - 29	292	80	31.4	3	8.1	83	28.4
	30 - 39	834	186	25.0	17	18.7	203	24.3
	40 - 49	859	143	19.2	15	13.3	158	18.4
	50 - 59	396	56	17.5	4	5.3	60	15.2
	60 - 69	89	18	28.1	1	4.0	19	21.3
	70 - 74	4	0	(0.0)	0	(0.0)	0	(0.0)
Total:		2 504	500	23.2	41	11.8	541	21.6

The total incidence was 19.3 per cent in women and 22.6 per cent in men. This difference is not significant (X^2=3.308, df=1), but in positive operations the sex difference, 20.4 and 24.4 per cent, was almost significant (X^2=3.954*,df=1). When the material was further separated by degree of herniation, the lower female incidence was repeated in all subgroups, except negative explorations. The correlation was not significant (X^2=0.854, df=3).

When correlated to the age at operation (Fig.6), the incidence of the sign was decreasing from 60.0 per cent in the youngest patients to 15.2 per cent in the age group 50-59 years. In the age group 60-69 years the incidence increased again to 21.3 per cent, but this increase occurred only at the level L4-L5. The negative correlation to age was highly significant (X^2=36.841***, df=4) and was repeated in both sexes, in positive and negative operations, and at both the low lumbar levels.

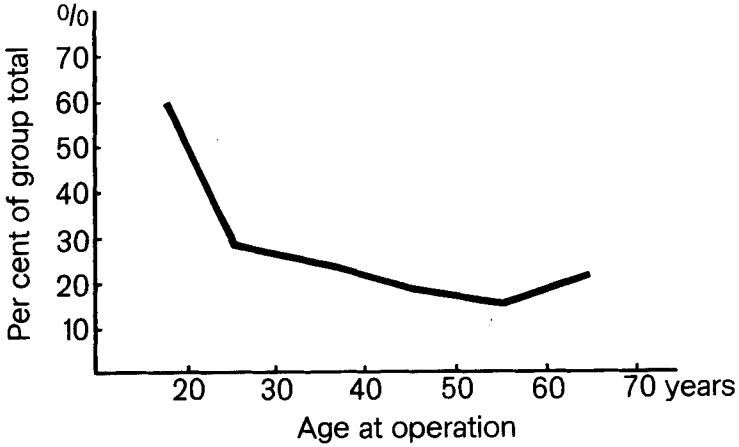

Fig. 6. The incidence of the crossed Lasègue's sign by age at operation in the total material.

The incidence of the sign was 11.8 per cent in negative explorations, 17.7 per cent in patients with a bulging disc, 21.3 per cent in incomplete herniations, and 27.1 per cent in complete herniations. This correlation is highly significant (X^2=36.536***,df=3).

In patients with herniations at the level L5-S1, the sign was positive in 22.5 per cent, at the level L4-L5 in 24.0 per cent. A higher incidence at the level L4-L5 was found in both women and men and in all age groups, but the difference between the two levels is not significant (X^2=0.710, df=1).

In 40 patients with herniations at the level L3-L4 the incidence was 22.5 per cent, while the sign was negative in five patients with herniations at the levels L1-L2 and L2-L3. The difference between the high lumbar levels and the two low levels is not significant (X^2=0.475, df=1).

In the total group of 61patients with verified multiple herniations, the incidence of the sign was 24.6 per cent, but the incidence was 35.3

per cent in patients with a combination of complete and incomplete herniations, 26.7 per cent if one of the herniations was a bulging disc, and 7.1 per cent in patients with two bulging discs.

Comments

i. As the crossed Lasègue's sign was often mentioned in the medical records only when positive, a certain underreporting of the sign may be expected in the present series. The total incidence of the sign in this material, 21.6 per cent, is, however, close to the average in 9 previous reports, but lower than the incidence, 33.2 per cent, found by WOODHALL & HAYES (1950) in a detailed study of this sign.

ii. The tendency to lower rates of the sign in women, which was observed in the ipsilateral Lasègue, also appears in the study of the crossed sign, although an almost significant sex difference was confirmed statistically only in the positive operations.

iii. Also the highly significant decrease in the incidence with age was repeated in the crossed sign. Contrary to the ipsilateral sign, the crossed Lasègue seems to increase again at the level L4-L5 in elderly patients; this increase is probably associated with an increasing rate of L4-L5 herniations with age.

iv. The highest rate of the crossed sign constantly appeared at the level L4-L5 in this analysis. The difference between the two low levels was not significant, but the trend agrees with previous observations (WOODHALL & HAYES, 1950).

v. Both the ipsilateral and the crossed Lasègue were correlated with high significance to the degree of herniation, but the crossed sign appears to be less sensitive and more specific for the preoperative diagnosis of disc herniation.

The rate of complete herniations was 34.3 per cent in patients with an ipsilateral Lasègue and 42.0 per cent in those with a crossed sign ($X^2=11.256^{***}$, df=1), and in this respect no other single sign surpassed the crossed Lasègue.

PREOPERATIVE NEUROLOGICAL SIGNS

For this study information was collected about the following neurological signs:

- monosymptomatic impairment of the ankle reflex
- monosymptomatic paresis of the dorsiflexion of the foot
- concomitant impairment of the ankle reflex and paresis
- absence of neurological signs
- impairment of the knee reflex
- the cauda equina syndrome.

The medical records were fairly uniform and extensive in the description of these signs. When specific information was missing on one of these points the function was assumed to be normal.

The subgroups with »impairment of the ankle reflex» contain all degrees of impairment of the reflex, except increased activity.

Similarly, the subgroups with »paresis of dorsiflexion» contain all degrees of motor weakness in the affected foot. Weakness of the hamstrings, the quadriceps femoris, and the calf muscles are excluded.

The subgroup without neurological signs contains no patients with impairment of the knee reflex or cauda equina syndromes. The possible occurrence of such signs together with impaired ankle reflex or paresis was not regarded in the three first groups.

Sensory changes and Lasègue's sign were disregarded in all groups.

ANKLE REFLEX AND PARESIS

Previous reports

Impairment of the ankle reflex was reported in 50 per cent of the patients already by BARR (1937), and in other reports during the following three decades this incidence keeps fairly constant with an average of 50 to 60 per cent.

On the contrary, the average incidence of paresis, as reported in surgical series, shows an unmistakable increase from approximately 15 per cent (*e.g.* BRADFORD & SPURLING, 1939) to about 50 per cent during the last 30 years; an increase, which is, no doubt, partly due to a growing clinical interest in this sign.

STÅHL (1949), in his study of 306 operations, broke these incidences down and found monosymptomatic impairment of the ankle reflex in 42.2 per cent, monosymptomatic paresis in 20.9 per cent, and

concomitant occurrence of the signs in 22.9 per cent. He also concluded that a monosymptomatic sign predicted the correct level of herniation in about 80 per cent, while concomitant signs occurred with equal frequency at the two lowest levels.

In spite of the clinical importance generally attached to these signs, surprisingly little is known about the correlation between the signs and the age of the patient. Apparently, it is often presumed that the diagnostic value of the signs is independent of the age.

The diagnosis of lumbar disc herniation is often accepted with reluctancy if all neurological signs are missing. In a survey of 10 previous reports with a total of 2.113 positive operations (App.table 6), the mean rate of herniations without preoperative neurological signs - apart from sensory changes and Lasègue's sign - was 19.2 per cent.

This report

The distribution of patients in the first four subgroups is specified by sex in Table 7.

Table 7. The incidence of patients with impaired ankle reflex, paresis of dorsiflexion, and without neurological signs by sex. (Frequencies and per cent of group total)

Preoperative neurology	Females		Males		Both sexes	
	no.	%	no.	%	no.	%
Monosymptomatic impairment of ankle reflex	231	31.2	513	29.1	744	29.7
Monosymptomatic paresis of dorsiflexion	220	29.7	535	30.3	755	30.2
Concomitant impairment of ankle reflex and paresis of dorsiflexion	135	18.2	298	16.9	433	17.3
No paresis or impairment of reflexes	147	19.8	381	21.6	528	21.1

Monosymptomatic impairment of the ankle reflex. The total incidence of this sign was 29.7 per cent with a sex distribution of 31.2 per cent in women and 29.1 per cent in men ($X^2=1.077$, df=1).

When correlated to age at operation, the incidence of the sign was low in the youngest patients, increased to the age of 35 years, and then decreased with age again (Fig. 7).

Monosymptomatic paresis of dorsiflexion. The total incidence was 30.2 per cent. Women had an incidence of 29.7 per cent and men 30.3 per cent (X^2=0.107, df=1).

Correlation of this incidence to age showed a decrease to the age of 35 years and then an increase again with age (Fig. 7).

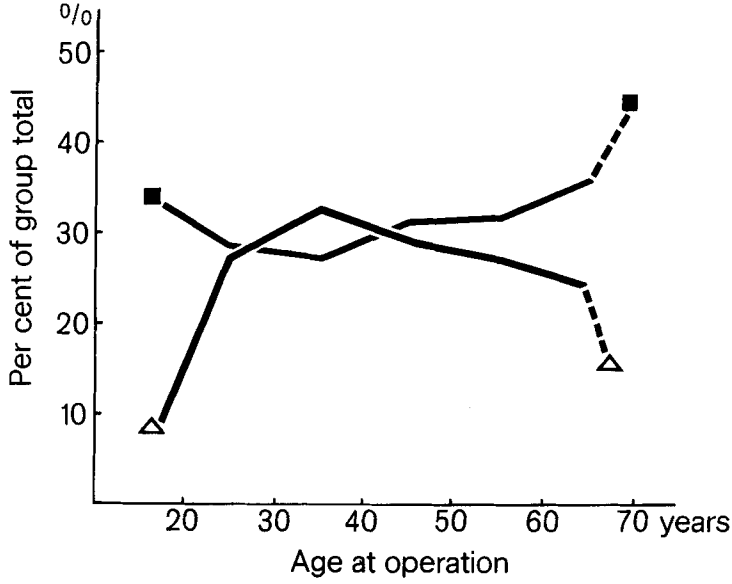

Fig. 7. The incidence of patients with monosymptomatic impairment of the ankle reflex (△) and monosymptomatic paresis of dorsiflexion (■) by age at operation. Dotted line indicates percentage calculation based on 10 or less cases.

Concomitant impairment of the ankle reflex and paresis. The total incidence of this combination of signs was 17.3 per cent. In women the incidence was 18.2 per cent and in men 16.9 per cent (X^2=0.631, df=1).

When correlated to age at operation, the incidence showed a pronounced positive correlation to age (Fig. 8).

Absence of neurological signs. The total incidence was 21.1 per cent with a sex distribution of 19.8 per cent in women and 21.6 per cent in men (X^2=0.985, df=1).

The correlation to age at operation was opposite to the former subgroup with a pronounced negative correlation to age (Fig. 8).

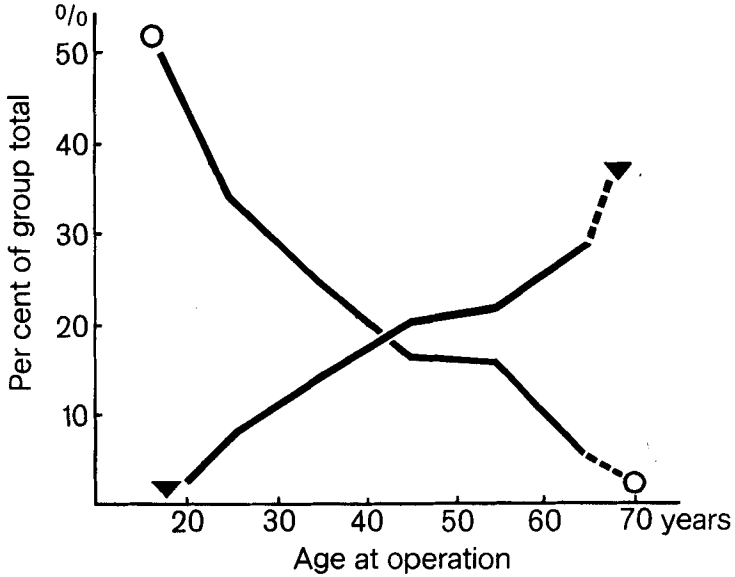

Fig. 8. The incidence of patients with concomitant impairment of the ankle reflex and paresis of dorsiflexion (▼) and without neurological signs (O) by age at operation.

Neurological signs and level of herniation. The following four graphs (Fig. 9-12) show the level of herniation by age at operations in each of the above-mentioned subgroups. The curves represent percentage distribution of herniations at the two low levels. The high lumbar herniations are omitted as the total number of cases in each subgroup is small.

In all the subgroups the rate of L5-S1 herniations tends to be highest in young patients and decrease with age, while the rate of L4-L5 herniations is lowest in young patients and increases with age. An exception from this general rule is seen particularly in patients without neurological signs (Fig. 12). This subgroup contains most of the juvenile patients, in whom the rate of L4-L5 herniations is higher than expected.

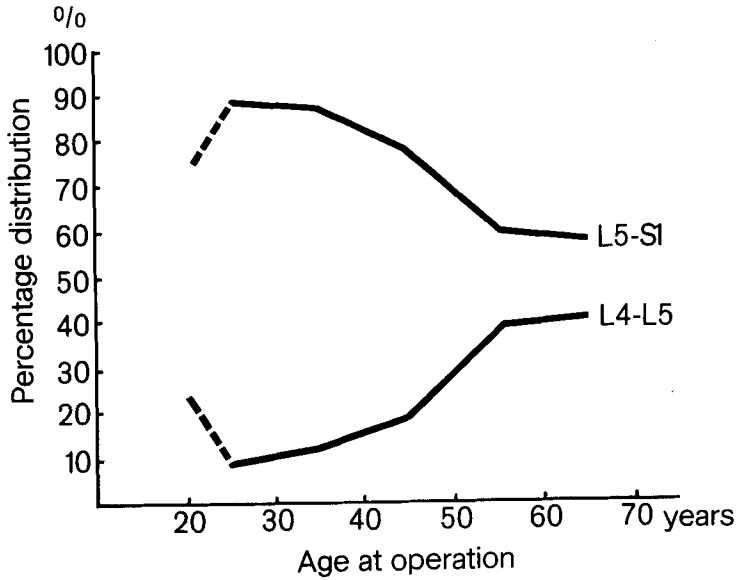

Fig. 9. The level of herniation by age at operation in patients with monosymptomatic impairment of the ankle reflex.

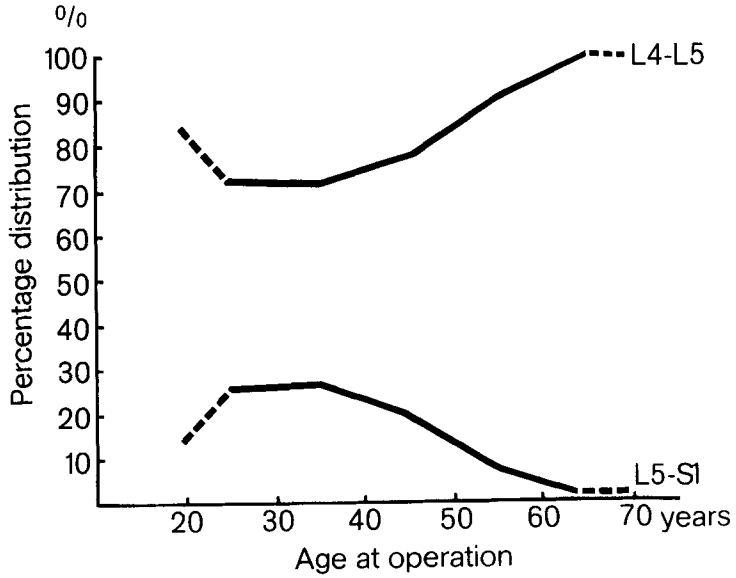

Fig. 10. The level of herniation by age at operation in patients with monosymptomatic paresis of dorsiflexion.

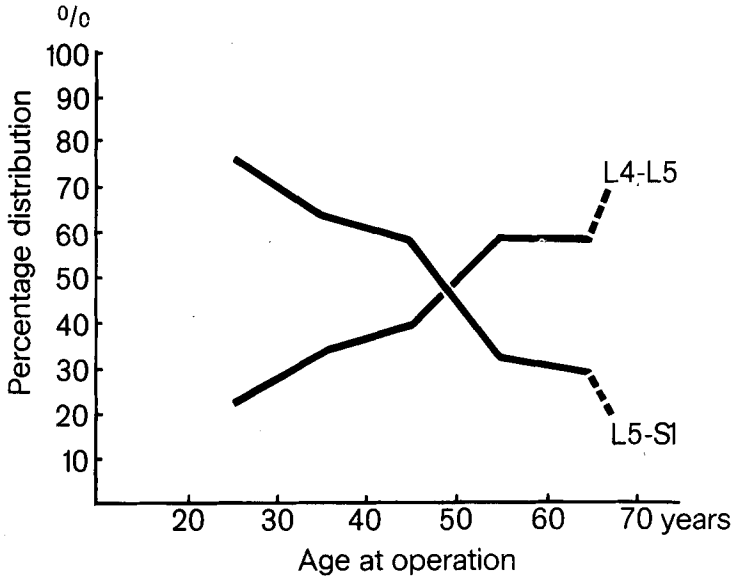

Fig. 11. The level of herniation by age at operation in patients with concomitant signs.

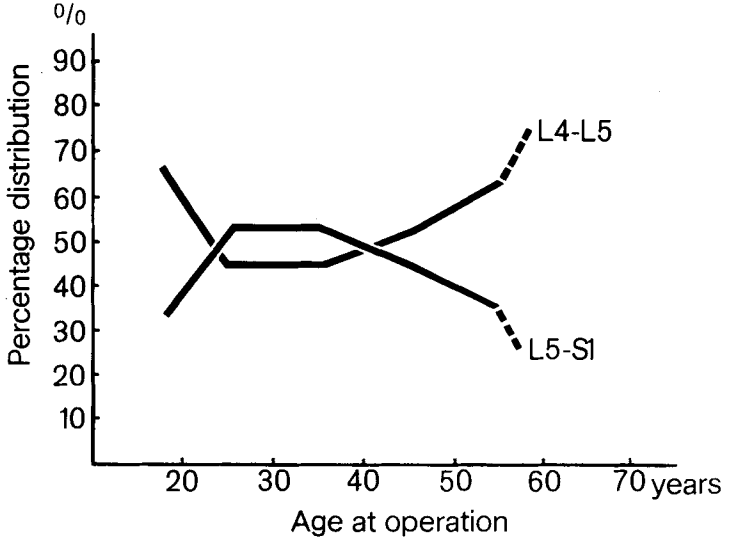

Fig. 12. The level of herniation by age at operation in patients without neurological signs.

Neurological signs and degree of herniation. In Table 8 the findings at operation are specified for each of the four subgroups.

Table 8. The degree of herniation in patients with impaired ankle reflex, paresis of dorsiflexion, and without preoperative neurological signs (Frequencies and percentage distribution)

Preoperative neurology	Total number of operations	Degree of herniation: Complete herniation no.	%	Incomplete herniation no.	%	Bulging disc no.	%	No herniation no.	%
Monosymptomatic impairment of ankle reflex	744	274	36.8	344	46.2	57	7.7	69	9.3
Monosymptomatic paresis of dorsiflexion	755	285	37.8	300	39.7	60	7.9	110	14.6
Concomitant impairment of ankle reflex and paresis	433	163	37.6	186	43.0	27	6.2	57	13.2
No paresis or impairment of reflexes	528	110	20.8	249	47.2	64	12.1	105	19.9

The rate of negative explorations was 9.3 per cent in the subgroup with monosymptomatic impairment of the ankle reflex and 14.6 per cent in the group with monosymptomatic paresis. This difference is significant (X^2=9.993 **, df=1) and was repeated in all age groups, except in patients over 60 years.

In the subgroup without preoperative neurological signs, the rate of negative explorations was 19.9 per cent, which is significantly higher than in the rest of the patients (X^2=20.436 *** , df=1). Further study of this subgroup shows that the rate of negative explorations was only 10.9 per cent if these patients had a positive myelogram and a positive Lasègue's sign, while it was 36,3 per cent if either one or both of these signs were negative.

Comments

i. The total incidences of the neurological signs studied in this section correspond to the average incidences reported in previous series, and the sex difference was insignificant in all the four subgroups.

ii. The interesting and characteristic patterns, which are found in each group when the neurological signs are correlated

to age at operation and level of herniation, open some new views on the diagnostic value of the preoperative neurology. These regular patterns are probably best explained by the fact that the process of disc herniation tends to begin at the lumbosacral level and proceed in the cranial direction with age (*cf.* Chap. V).

iii. Apart from the juvenile group, which does not follow the common pattern, this explains why impairment of the ankle reflex is most common - and most reliable as a diagnostic sign - in the younger patients. As the sign often persists after an attack of sciatica, the diagnostic value is decreasing with age, and a persistent sign may confuse the neurological picture if the patient develops a herniation at the level L4-L5 later on.

iv. In the subgroup with monosymptomatic paresis of dorsiflexion, the rate of L4-L5 herniations is, accordingly, increasing from 70 per cent in the age group 20-39 years to a hundred per cent after the age of 60 years. This group had a significantly higher rate of negative explorations than the former, and a detailed study indicates that the incidence of negative explorations is particularly high in the age group 20-39 years. It is, therefore, possible that this sign tends to be misleading in the younger patients.

v. An almost complete, positive correlation between age and level of herniation appears in the patients with concomitant signs. Further study of this subgroup indicates that the diagnostic value tends to decrease with age.

vi. Contrary to the concomitant signs, the occurrence of herniations without neurological signs was highest in the juvenile patients and decreased rapidly with age.

The rate of negative explorations was significantly higher in patients without neurological signs than in the other subgroups, and the increased risk of negative exploration was traced to those patients who had a negative myelogram, a negative Lasègue, or both.

vii. In a separate analysis of the three first subgroups it was found that the occurrence of an impaired knee reflex, which was primarily disregarded, never changed the distributions more than 2 per cent.

viii. In general, this study of the neurological signs shows that a considerable improvement may be expected in the accuracy of the preoperative diagnosis if the age of the patient is considered in the preoperative judgment of the neurological signs.

THE KNEE REFLEX

Previous reports

In a survey of 20 previous reports with a total of 4.822 operations, the average incidence of impaired knee reflex was 8.4 per cent (App. table 7).

The average incidences of impaired knee reflex by herniations at different levels were studied in another survey. In 17 reports with a total of 3,131 operations, the incidence was 47.5 per cent in patients with herniations at the level L3-L4, 6.9 per cent at the level L4-L5, and 5.3 per cent at the level L5-S1 (App.table 8).

As a diagnostic sign of disc herniation, impairment of the knee reflex has a dubious reputation. The value of the sign for prediction of herniations at the level L3-L4 was questioned already by FRIBERG (1941), who observed that five patients with impairment of this reflex had herniations at the level L4-L5, while three high lumbar herniations did not show the sign.

Herniations at the level L2-L3 are rare, but in five reports with 29 operations the sign was positive in 10 patients or 34.5 per cent (App.table 9).

This report

The subgroup with »impairment of the knee reflex» contains all degrees of impaired knee reflex in the affected leg, except increased activity. In this sense the sign was registered before the operation in 105 patients or 4.2 per cent of all cases (Table 9). The incidence was 3.0 per cent in women and 4.7 per cent in men ($X^2=3.927$ *, df=1).

The department in Härnösand had a total mean incidence of 3.0 per cent, but the annual incidence was decreasing from 7.9 per cent in 1952 to 1.1 per cent in 1958 and then increasing again to 6.4 per cent in 1966.

This peculiar change in the incidence probably reflects a period of distrust in the clinical value of the sign among the orthopaedic surgeons. The department in Umeå had a mean incidence of 9.7 per cent. At both departments the sign was monosymptomatic in one third of the cases.

A correlation to age at operation shows a high incidence in the

Table 9. The total incidence of patients with impaired knee reflex by sex and series (Frequencies and per cent of group total)

Series	Females		Males		Both sexes	
	no.	%	no.	%	no.	%
H.I	8	2.6	20	2.5	28	2.5
H.II	8	2.5	27	4.3	35	3.7
Umeå	6	5.0	36	11.4	42	9.7
Total:	22	3.0	83	4.7	105	4.2

youngest patients, decrease to a lowest rate at the age of 35 years, and then an increase with age again (Fig. 13). This pattern was repeated in both positive and negative operations and also when the series were studied separately.

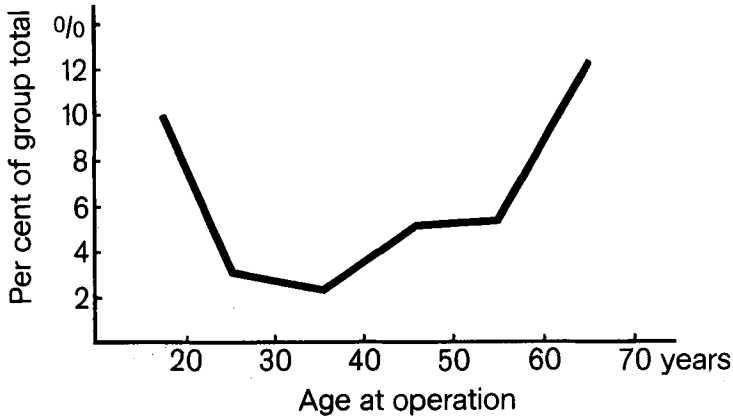

Fig. 13. The incidence of patients with impaired knee reflex by age at operation in the total material.

In 90 patients with verified herniations and impairment of the knee reflex, the herniations were located at the high lumbar levels in 24.4 per cent. The subgroup of 34 positive cases with monosymptomatic impairment of the knee reflex had the highest rate of high herniations, 36.3 per cent, but even in this group most of the herniations were located at the two low levels. When the level of herniation was correlated to age at operation in these 90 patients, the herniations were located at the level L5-S1 before the age of 40 years, after which the rate of L4-L5 and higher herniations increased constantly.

In 40 patients with verified herniations at the level L3-L4, the knee reflex was impaired in 50.0 per cent, while the incidence was only

4.3 per cent at the level L4-L5 and 2.3 per cent at the level L5-S1.

In the total group of 105 patients with impairment of the knee reflex, complete herniation was found in 20.0 per cent, incomplete herniation in 52.4 per cent, bulging discs in 13.3 per cent, and 14.3 per cent were negative explorations.

Comments

i. In previous series the mean incidences of the sign range from 0 to 30 per cent, and this variability is probably caused by different opinions on the clinical value of the sign. A similar trend was observed in a longitudinal study of the series from Härnösand.

ii. The present study confirms that although 50 per cent of the patients with L3-L4 herniations have impairment of the knee reflex, the sign is of limited value for prediction of the level of herniation, as it is more often associated with herniations at the two low levels.

iii. When the incidence of the sign is correlated to the age at operation, the pattern is rather similar to that of paresis of dorsiflexion, *i.e.* high rates in the juvenile patients, the lowest rates in younger patients and then a constant increase with age.

THE CAUDA EQUINA SYNDROME

Strictly speaking, all neurological signs from the lumbar disc herniations may be designated as partial cauda equina syndromes, but as usual, the term is applied here to indicate neurological signs referable to the 2nd and lower sacral roots.

Previous reports

In a survey of 31 reports with a total of 15,556 operations, the average incidence of cauda equina syndromes was 2.4 per cent (App.table 10).

This incidence decreased from 3.7 to 1.7 per cent during the last three decades, and in 90 cases published during the years 1937-39 the incidence was 11.1 per cent. Most cases published before MIXTER & BARR (1934) were severe cauda equina syndromes, and it is not surprising that surgical attention was first drawn to the pathology of the intervertebral discs by these dramatic cases.

In a total of 187 operations on patients with cauda equina syndromes from 18 previous reports, the herniations were located at

the level L5-S1 in 36.9 per cent, at the level L4-L5 in 46.0 per cent, and at the levels L2-L4 in 17.1 per cent (App.table 11). This rate of high lumbar herniations is considerably higher than in complete disc series.

This report

In the present series, cauda equina syndromes were registered before the operation in 31 patients or 1.2 per cent. The group contained 10 women and 21 men.

In most cases impairment of the visceral functions, particularly bladder paralysis, was a dominant feature, but the complicated neurological picture in these patients was not analysed in detail.

The mean age at operation in this subgroup was 40.9 years as compared with 40.8 years in the total material. This difference is not significant ($p > 0.05$).

In this group of 31 operations, a complete herniation was found in 15 cases, an incomplete in 11 cases, and five operations were negative explorations. There were no bulging discs and no multiple herniations.

The 26 herniations were located at the level L5-S1 in 12 cases, at the level L4-L5 in 11 cases, and 3 - or 11.5 per cent - were high lumbar herniations at the levels L3-L4 or L2-L3. As compared with the total material, the rate of high lumbar herniations is significantly increased in patients with cauda equina syndromes ($X^2 = 7.303^{**}$, df=1).

Comments

i. The series of patients with cauda equina syndromes are still too small for valid statistical conclusions, but the present study does not suggest any notable difference in sex distribution or age at operation when these patients are compared with complete disc series.

ii. In most cases the offending disc herniation is located at one of the two low levels, but there is little doubt that the rate of high lumbar herniations is significantly increased in patients with cauda equina syndromes.

iii. It might be expected that high lumbar herniations with cauda equina compression would always cause gross neurological damage, but it is interesting to notice that two of the three high herniations in this subgroup produced a monosymptomatic sacral syndrome.

CHAPTER V

THE LEVEL OF HERNIATION

Previous reports

A study of 49 publications with a total of 15,235 operations confirms that most of the lumbar herniations are found at the two low levels (App.table 12). The average distribution in this survey was 46.9 per cent at the level L5-S1, 49.8 per cent at the level L4-L5, and 3.3 per cent high lumbar herniations.

Curiously enough an estimation of the trend during the last 30 years indicates a constant change in the proportion of herniations at the two low levels: L4-L5 herniations increased from 44.5 to 53.5 per cent and L5-S1 herniations decreased correspondingly from 52.1 to 42.9 per cent.

The sex difference in level of herniation has been studied by several authors without uniform conclusions. REYNOLDS *et al.* (1959) showed that in women the majority of the disc lesions were located at the level L4-L5, but no predilection appeared in men. FRASER (1966) and VIERNSTEIN *et al.*(1966) found no sex difference, while DIEMATH & HEPPNER (1958) and SPARUP (1960) concluded that women had a higher incidence of L5-S1 lesions than men.

Althougt several authors (*e.g.* NORLÉN 1927, HIRSCH & SCHAJOWICZ 1953, HARMON & ABEL 1963) have pointed out that disc degeneration usually proceeds cranially from the lumbo-sacral level with age, only little information is available about the correlation between the age at operation and the level of herniation. However, a few investigations of this problem (PEYTON & SIMMONDS 1947, VIERNSTEIN *et al.* 1966) have failed to demonstrate any such correlation between age and level of herniation.

This report

The level of herniation is specified by sex and degree of herniation in Table 10. The total distribution of herniations in this material was 50.5 per cent at the level L5-S1, 47.4 per cent at the level L4-L5, and 2.1 per cent high lumbar herniations.

The preponderance of L5-S1 herniations is mainly caused by the women, in whom the rates are 53.1 per cent at the level L5-S1 and 45.4 per cent at the level L4-L5. In men the distribution is more equal-49.4 per cent and 48.2 per cent. This sex difference is not significant ($X^2 = 1.928$, df=1).

Further separation by degree of herniation shows that men have a distribution without significant difference between the two lowest levels by all degrees of herniation (X^2=0.099, df=2). In women the incidence of L5-S1 herniations is increasing with decreasing degree of herniation, and this difference in the distribution is almost significant (X^2=8.252 *,df=2).

Table 10. The level of herniation by sex and degree of herniation (Frequencies and percentage distribution)

Degree of herniation	Level of herniation	Females		Males		Both sexes	
		no.	%	no.	%	no.	%
Complete herniation	L1 - L4	3	1.3	16	2.7	19	2.3
	L4 - L5	125	52.1	287	48.0	412	49.2
	L5 - S1	112	46.6	295	49.3	407	48.5
	Total:	240	100.0	598	100.0	838	100.0
Incomplete herniation	L1 - L4	6	1.8	14	1.8	20	1.8
	L4 - L5	145	42.8	370	48.4	515	46.7
	L5 - S1	188	55.4	381	49.8	569	51.5
	Total:	339	100.0	765	100.0	1 104	100.0
Bulging disc	L1 - L4	0	0.0	6	3.9	6	2.8
	L4 - L5	22	34.9	74	48.7	96	44.7
	L5 - S1	41	65.1	72	47.4	113	52.5
	Total:	63	100.0	152	100.0	215	100.0
All positive operations	L1 - L2	1	0.2	0	0.0	1	0.05
	L2 - L3	1	0.2	3	0.2	4	0.2
	L3 - L4	7	1.1	33	2.2	40	1.8
	L4 - L5	292	45.4	731	48.2	1 023	47.4
	L5 - S1	341	53.1	748	49.4	1 089	50.5
	Total:	642	100.0	1 515	100.0	2 157	100.0

The total rate of L4-L5 herniations increased from 45.5 per cent in series H.I to 48.9 per cent in series H.II. This increase is not significant (X^2=0.607, df=2), and a longitudinal study of the period 1951-66 (Fig. 14) does not confirm that the trend is particularly characteristic (X^2=8.342, df=7).

The mean age at operation at the different levels is specified in Table 2. The study shows a constant pattern of increased mean age with

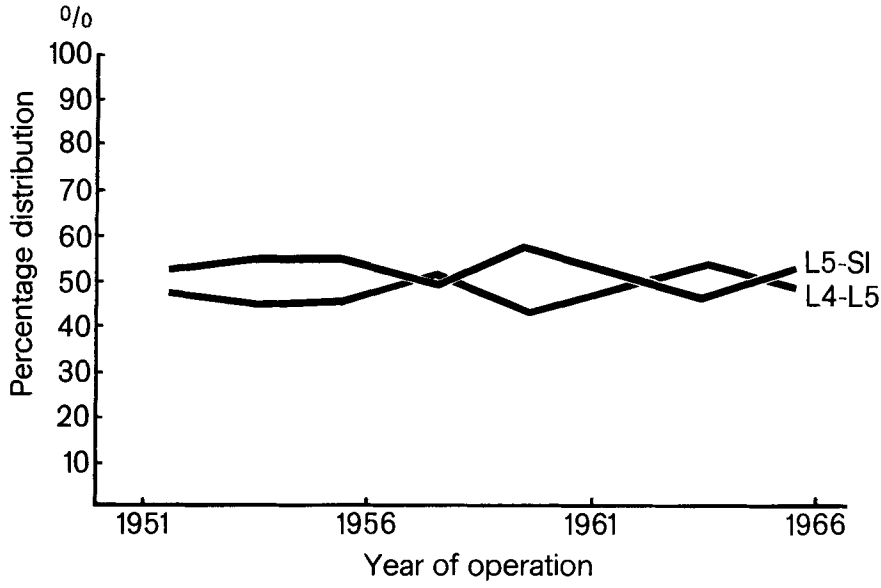

Fig. 14. The annual distribution of herniations at the two lowest levels in series H.I-II (Härnösand 1951-66).

the level of herniation in the cranial direction. The increase in mean age is highly significant between the two low levels and between the levels L5-S1 and L3-L4 ($p < 0.001$), not significant between the levels L4-L5 and L3-L4 ($p > 0.05$).

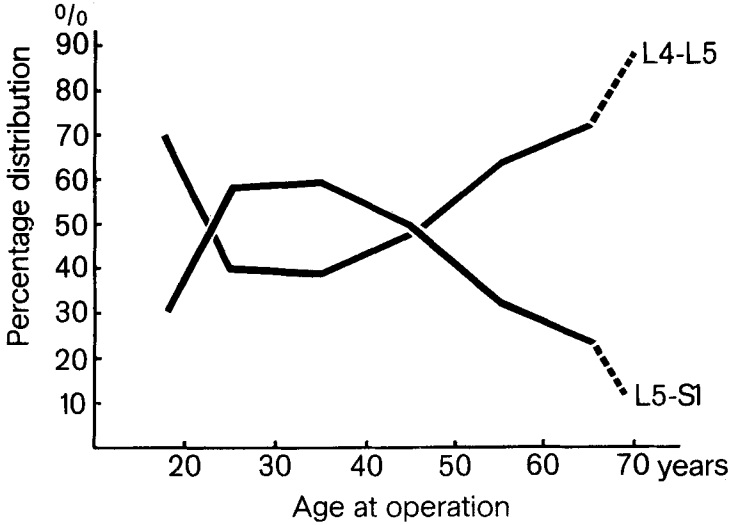

Fig. 15. The level of herniation by age at operation in the total material.

In men the mean interval is 3.8 years between the two low levels, and 5.0 years between L4-L5 and L3-L4.

As mentioned before (p.15) the total mean age at operation increased during the period 1951-66. When the mean age is studied separately at the levels L5-S1 and L4-L5, it appears that this increase in mean age is repeated with little difference at both the low levels.

The correlation between level of herniation and age groups is illustrated in Fig. 15.

The incidence of L5-S1 herniations is low in juveniles, increases rapidly to the age of 25, and from 35 years again decreases constantly with age. In L4-L5 herniations this pattern is reversed - the incidence is high in the juveniles, lowest in the age group 25-34 years, and then increases constantly with age.

The pattern of the high lumbar herniations (Fig. 16) is similar to that of L4-L5 herniations with a rather high incidence in the age group 20-24 years, a low incidence in the age group 30-34 years, and then a significant increase with age (X^2=15.076 ** , df=4).

Fig. 16. The incidence of high lumbar herniations by age at operation.

Comments

i. The study of previous reports showed a notable increase in the proportion of herniations at the level L4-L5 and a corresponding decrease at the level L5-S1 during the last three decades. A similar trend is hardly discernible in the present

material, although there is an insignificant increase of L4-L5 herniations when series H.I and series H.II are compared.

ii. When all positive operations are considered, there is no significant sex difference between the distributions of herniations at the two lowest levels in this material. The possibility of a sex difference is, however, indicated by a more detailed analysis of the correlation between level and degree of herniation, as women have an almost significant increase in the incidence of L5-S1 herniations with decreasing degree of herniation. Men, on the other hand, have an equal distribution of herniations at the two low levels by all degrees of herniation. The present analysis suggests no convincing explanation to a possible sex difference of this type.

iii. The most interesting information gained from this part of the study is, no doubt, the observation that the mean age at operation is increasing significantly with the level of herniation, or, in other words, that the process of disc herniation tends to begin at the lumbo-sacral level and proceed in the cranial direction with increasing age.

iv. Further analysis of the correlations between age groups and the levels of herniation confirms this rule, but also reveals that the juvenile patients represent an exception with high rates of herniations at the level L4-L5 and perhaps even of high lumbar herniations.

v. The discovery of these regular patterns in the correlation between age and level of herniation improves the accuracy of the preoperative diagnosis, adds to the understanding of recurrent herniations, and may also contribute to a better understanding of the patho-anatomical process of disc herniation.

vi. The common occurrence of an interval between the development of herniations at different levels is illustrated by the fact that two complete herniations at different levels were never found at one operation in this material.

CHAPTER VI
THE DEGREE OF HERNIATION

Classification

Herniation of the intervertebral disc is a continuous process, and it is necessary to accept some arbitrage in a descriptive classification of the degree of herniation.

In the literature a variety of terms have been used to describe these lesions, but the semantic structure is similar in most nomenclatures and may be summarized in the following categories which are also applied in the present report:

Complete herniation. This lesion is characterized by spontaneous rupture of the posterior longitudinal ligament and extrusion of sequestrated disc tissue. In most cases the rupture is easily recognized by the surgeon, and the surgical report allows a valid classification. Occasionally it is difficult to establish whether the rupture occurred before or during the operation, and it seems reasonable to accept as "complete herniations" also cases in which the rupture occurred spontaneously during exposure of the intervertebral space. All cases with rupture caused by incision or blunt pressure on the disc should, however, be classified as "incomplete".

No herniations were classified as "complete" for this analysis unless explicitly so described by the surgeon.

Incomplete herniation. This is a well defined, circumscribed lesion, clearly protruding beyond normal anatomical limits. The typical case is easily recognized at the operation — and mecnanical involvement of a nerve root is usually verified — but the distinction between less pronounced incomplete herniations and bulging or degenerated discs is naturally subject to considerable observer variability.

Bulging disc. This is the most equivocal category and may not be accepted as a true disc herniation. The term should imply demonstration of a generalized bulge of the disc, protruding beyond anatomical limits and presumably large enough to cause mechanical pressure on the adjacent nerve root. Obviously, it is impossible to formulate a quite satisfactory distinction between this type of disc lesion and the common disc degeneration with reduced intervertebral space, scarred surface, bony spurs, and, in many cases, adherent root sheets.

Negative explorations. The present study is primarily concerned with the clinical syndromes caused by protrusion or frank rupture of

the intervertebral discs, and the terms "negative exploration" and "negative operation" are used here in the limited sense that no part of the discs was protruding into the vertebral canal beyond anatomical limits. The terms do not refer to other pathological changes of the discs or the surrounding structures observed during the operation.

Previous reports

The incidence of patients with complete herniation was tabulated from 15 reports with a total of 5,275 operations (App.table 13). In this survey, which includes the negative explorations, the mean rate of complete herniations was 35.7 per cent. This rate is apparently increasing as the mean was 27.3 per cent before 1950 and 39.4 per cent after.

The incidence of negative explorations in 44 previous reports with a total of 14,065 operations was 9.2 per cent (App.table 14). When these series are summarized by decennia, the mean rate of negative explorations is decreasing from 12.7 per cent to 7.3 per cent during the last 30 years.

The sex difference in degree of herniation was studied by FRASER (1966) and GOODSELL (1967). In both series complete herniations were found with equal incidence in women and men.

Little information is available about the correlation between the age at operation and the degree of herniation. FRASER (1966), however, observed that acute herniations did not increase with age.

The correlation between the level and the degree of herniation has been studied by a few authors. BROWN & PONT (1963) and FRASER (1966) found the highest rate of complete herniations at the lowest level, while LYERLY & GRIZZARD (1948) and ROBINSON (1965) reported that the incidence of complete herniations was increasing with the level of herniation in the cranial direction.

This report

In patients with multiple herniations only the main lesion, as judged by the degree of herniation, was registered for this part of the analysis.

The degree of herniation is specified by sex in Table 11. The total incidences are 33.5 per cent complete herniations, 44.1 per cent incomplete herniations, 8.6 per cent bulging discs, and 13.8 per cent negative explorations. There was no significant sex difference in the degree of herniation when all women and all men were compared ($X^2=1.219$, df=3).

Table 11. The degree of herniation by sex (Frequencies and percentage distribution)

Sex	Total number of operations	Degree of herniation: Complete herniation no.	%	Incomplete herniation no.	%	Bulging disc no.	%	No herniation no.	%
Females	741	240	32.4	339	45.7	63	8.5	99	13.4
Males	1 763	598	33.9	765	43.4	152	8.6	248	14.1
Total:	2 504	838	33.5	1 104	44.1	215	8.6	347	13.8

A longitudinal study of the series H.I-II (Fig. 17) shows a constant increase in the rate of complete herniations and a corresponding decrease in the rate of incomplete herniations during the period. The difference is highly significant (X^2=68.174 *** , df=7), and the trend was broken only during the years 1957-59, when the rates of bulging discs and, particularly, negative explorations were unusually high.

The mean age at operation is specified by degree of herniation in Table 2. In the total group with incomplete herniations the mean age at operation was 39.5 years, in complete herniations 41.4 years, and in negative explorations 43.3 years. The difference is highly significant between patients with incomplete and complete herniations and between patients with incomplete herniations and negative explorations ($p < 0.001$), almost significant between patients with complete herniations and negative explorations ($p < 0.05$).

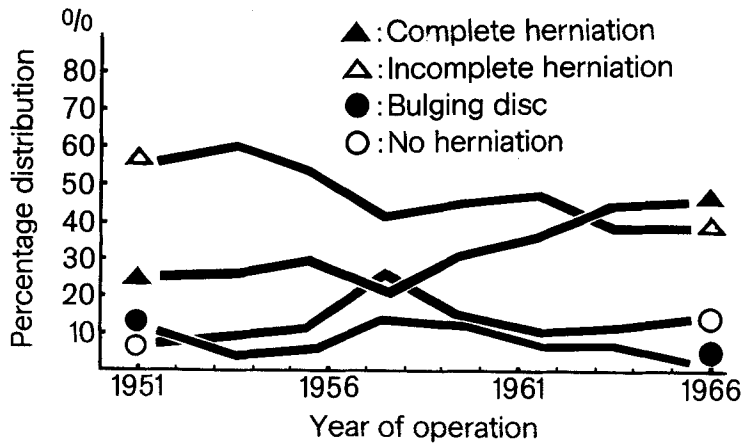

Fig. 17. The degree of herniation by year of operation in series H.I-II (Härnösand 1951-66).

In Table 12 the patients are further separated by level of herniation. By all degrees of herniation the mean age is higher at the level L4-L5 than at the level L5-S1. The difference is most pronounced by the highest degrees and highly significant in the subgroups with complete and incomplete herniations ($p < 0.001$). In the subgroup with bulging discs the difference in mean age between the two low levels is not significant ($p > 0.05$).

Table 12. The mean age at operation by level and degree of herniation

Level of herniation	Total number of operations	Degree of herniation: Complete herniation no.	Complete herniation Mean age (years)	Incomplete herniation no.	Incomplete herniation Mean age (years)	Bulging disc no.	Bulging disc Mean age (years)
L4 - L5	1 023	412	43.5	515 [1]	40.9	96	41.7
L5 - S1	1 089	407	39.0	569	38.2	113	40.4
Difference between L4-L5 and L5-S1:		4.5 years		2.7 years		1.3 years	

1) This subgroup contains 16 juvenile patients; if these are excluded the mean age is 41.8 years and the difference 3.6 years

The correlation between degree of herniation and age at operation is illustrated in Fig. 18. The rate of incomplete herniations is high in the

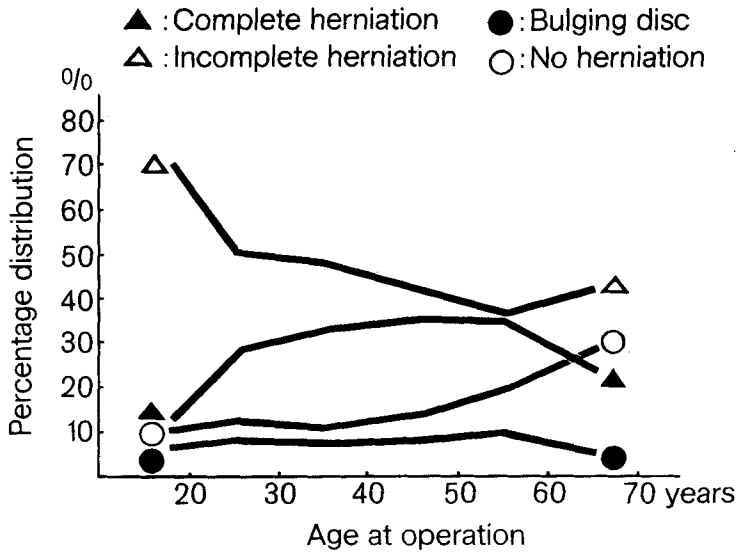

Fig. 18. The degree of herniation by age at operation in the total material.

youngest patients and decreasing constantly to the age of 55 years, while the rate of complete herniations is increasing constantly to the age of 55 and the decreasing again. The difference between these two distributions is significant (X^2=18.070 ** , df=4).

The rate of bulging discs seems to be largely independent of the age at operation, even when the levels are separated.

The rate of negative explorations is 10 per cent in juveniles, fairly constant around 12.5 per cent in the age group 20-49 years, and then increasing to reach 35 per cent in the age group 65-69 years. This increase in the rate of negative explorations with age is highly significant (X^2=34.355 ***,df=4).

When the levels are separated, the correlation between degree of herniation and age shows characteristic differences at the two lowest discs.

At the level L5-S1 (Fig. 19) the incidence of incomplete herniations is increasing to the age of 25 years and then decreasing; the incidence of complete herniations follows a similar course with a delay of some years.

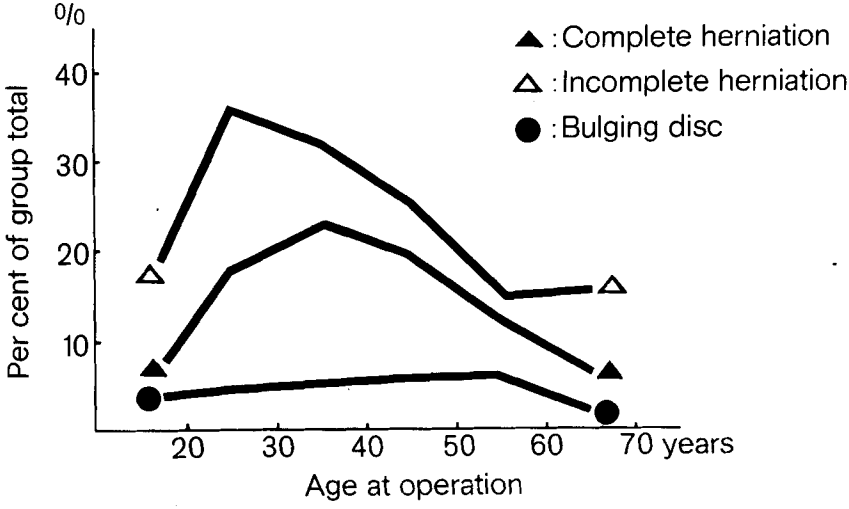

Fig. 19. The degree of herniation at the level L5-S1 by age at operation.

At the level L4-L5 (Fig. 20) the incidence of incomplete herniations is high in the youngest patients, drops sharply to a low and rather constant rate between 25 and 45 years, and then increases again. The incidence of complete herniations shows a fairly constant increase with age to 55 years and then decreases.

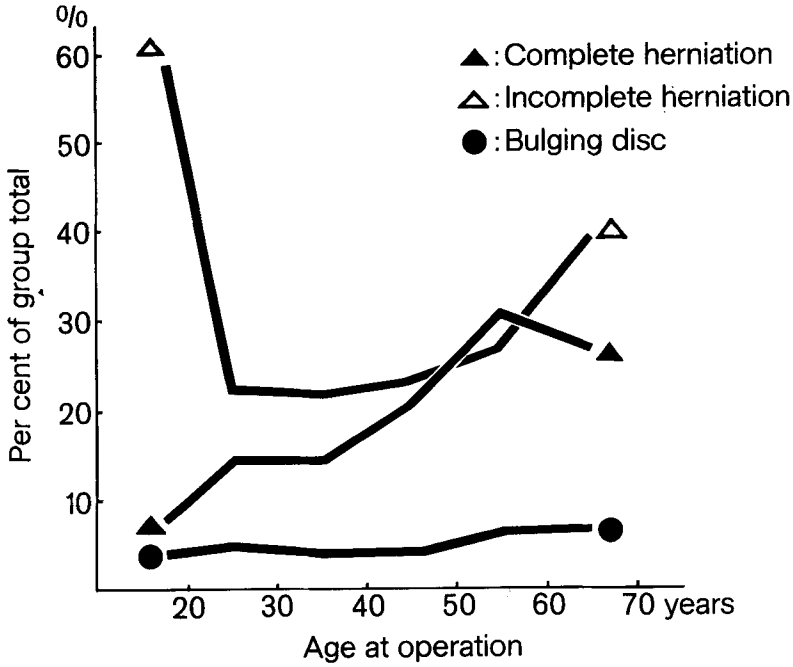

Fig.20. The degree of herniation at the level L4-L5 by age at operation.

When the incidence of complete herniations by level and age (Fig. 21) is compared with a similar analysis of incomplete herniations (Fig. 22), it appears that these two types of herniation follow a similar pattern of distribution: L5-S1 herniations are most common in young patients and decrease with age, L4-L5 herniations are increasing with age and most common in the elderly. This correlation between age and level is, however, most pronounced in patients with complete herniations. Moreover, the subgroup with incomplete herniations contains the juveniles, in whom the correlation to level of herniation is reversed.

In Table 13 the degree of herniation is correlated to the level of herniation. The trends indicate that the proportion of complete herniations is increasing in the cranial direction, while the proportions of incomplete herniations and bulging discs are highest at the lumbo-sacral level and decreasing in the cranial direction. The difference in these distributions is not significant ($X^2=3.106$, df=4).

In the subgroup of 347 negative explorations, the level L5-S1 was explored 307 times, the level L4-L5 285 times, and the high lumbar levels 31 times.

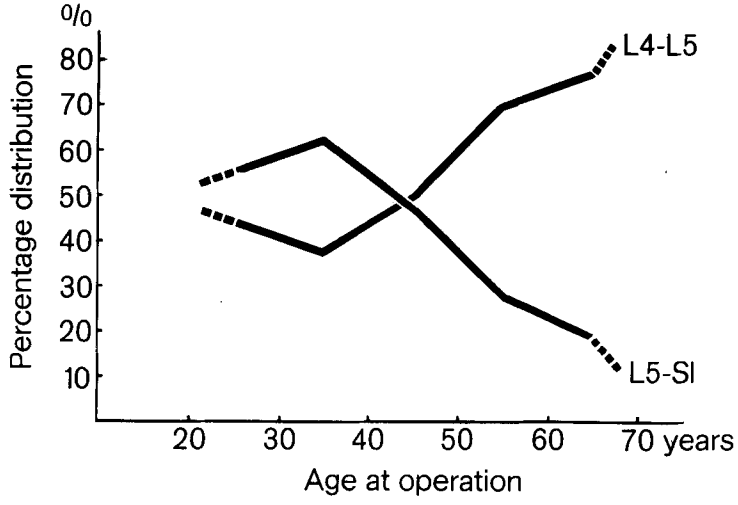

Fig.21. The level of herniation in patients with complete herniations by age at operation (percentage distribution).

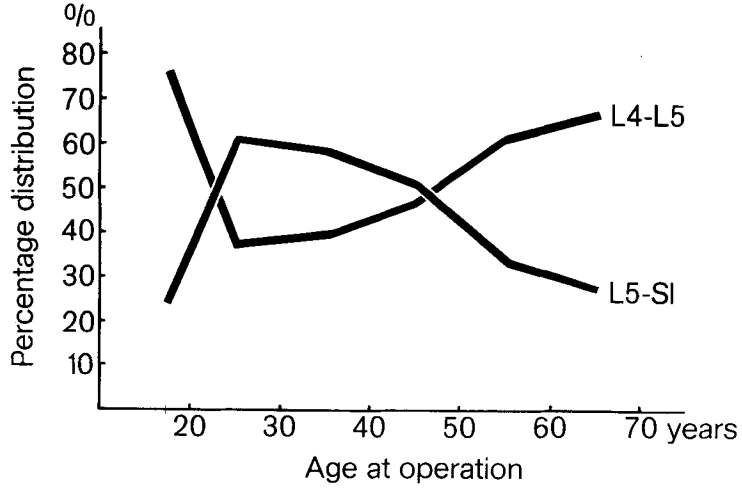

Fig.22. The level of herniation in patients with incomplete herniations by age at operation (percentage distribution).

Table 13. The degree of herniation in positive operations by level of herniation (Frequencies and percentage distribution)

Level of herniation	Total number of operations	Degree of herniation: Complete herniation		Incomplete herniation		Bulging disc	
		no.	%	no.	%	no.	%
L1 - L3	5	1	(20.0)	1	(20.0)	3	(60.0)
L3 - L4	40	18	45.0	19	47.5	3	7.5
L4 - L5	1 023	412	40.3	515	50.3	96	9.4
L5 - S1	1 089	407	37.4	569	52.2	113	10.4
Total:	2 157	838	38.8	1 104	51.2	215	10.0

Comments

i. In the present series the total mean rate of complete herniations, 33.5 per cent, is close to the average, 35.7 per cent, in 15 previous reports.

ii. There was no significant sex difference in the degree of herniation in these series. This observation is also in agreement with previous investigations.

iii. The rate of complete herniations increased with high significance during the period 1951-66. A similar trend was found in the survey of previous reports from the last 30 years.

iv. In general, incomplete herniations occur at an earlier age than complete herniations. This pattern was repeated at both the common levels, and the difference was highly significant.

As the process of herniation tends to begin at the lumbo-sacral level, the mean ages for the different degrees of herniation are, however, higher at the level L4-L5 than at the level L5-S1.

For patients with complete herniations the difference in mean age between the two low levels was 4.5 years, which is highly significant. In the subgroup with incomplete herniations, the difference was only 2.7 years, but this is partly explained by an unexpected high number of juvenile patients with incomplete herniations at the level L4-L5. Even so, the difference is still highly significant.

v. Contrary to the true herniations, the incidence of the controversial "bulging discs" was almost independent of the age at operation, and the present study does not indicate that the

bulging disc is, in general, a precursor of the incomplete herniation.

vi. The highest mean age at operation was found in patients with negative explorations. The incidence of negative explorations increased with age, the increase was highly significant and most pronounced after the age of 50 years. At this age most of the preoperative signs lose diagnostic value and the rate of false positive myelograms is increasing.

vii. In these series the rate of complete herniations seems to increase, the rates of incomplete herniations and bulging discs to decrease, in the cranial direction. This correlation was not significant, and even if the trend is correct it does not necessarily reflect the true patho-anatomical situation. The clinical picture caused by a disc herniation and the diagnostic value of myelographic examination vary considerably at the different levels, which may affect the selection of patients for operation.

CHAPTER VII

THE RESULT OF OPERATION

Previous reports

A detailed survey of the late results in 35 previous reports with a total of 13,452 operations was tabulated by JOCHHEIM *et al.* (1961). In this survey excellent and good results range from 50 to95 per cent, unsatisfactory results from 3 to 50 per cent with an average of approximately 10 per cent. Different reports are, however, seldom comparable in this respect as the criteria for measuring the result of operation are applied in a large variety of combinations.

The only criterium used in common by a considerable number of authors was found to be »complete relief of all symptoms». In a survey of 21 previous reports with a total of 4,887 operations, the mean rate of »complete relief» was 46.2 per cent, ranging from 12.9 to 68.7 per cent in the individual reports (App.table 15). This mean rate was 43.4 per cent in 12 reports before 1950 and 49.8 per cent in 9 reports after 1950.

Most authors agree that sex and age are factors of minor importance for the result of operation. In some reports, however, the best results are found in men (*e.g.* REYNOLDS *et al.* 1959, SPARUP

1960, WEBER 1970), and in the younger age groups (*e.g.* GOTTSCHALCK &HÖJGAARD 1961, MARSHALL & SCHORSTEIN 1968).

Many authors are aware of the possibility that the level of herniation may influence the surgical prognosis, but the conclusions are contradictory. Most investigations have failed to demonstrate a correlation between level and results (*e.g.* DECKER & SHAPIRO 1957, ANDERSSON *et al.* 1961, SHENKIN & HAFT 1966, WHITE 1966, MARSHALL & SCHORSTEIN 1968). The best results were, however, found at the level L5-S1 by CAMPBELL & WHITFIELD (1947) and DIEMATH & HEPPNER (1958), while DePALMA & GILLESPY (1962) concluded that long-term results were better at the level L4-L5.

The degree of herniation is, generally, considered of principal importance for the surgical prognosis: patients with complete herniations having the best results, and negative explorations the poorest (*e.g.* MIXTER 1937, BRADFORD & SPURLING 1947, BURNS & YOUNG 1951, GURDJIAN *et al.* 1961, HIRSCH 1965, SLEPIAN 1966, TRILLAT *et al.* 1967). There are, however, some dissenters from this opinion. DECKER & SHAPIRO (1957) and PALAZZO (1960), for instance, found no significant correlation between the results and the degree of herniation.

Also in the study of persistent low back pain after disc operations previous reports differ in definitions and criteria, but most investigations have an incidence between 20 and 45 per cent (*e.g.* POPPEN 1945, LOVE 1947, WEBER 1950, SÖDERBERG & SJÖBERG 1961, KNIGHTON & HITSELBERGER 1964, VIERNSTEIN *et al.* 1966, BÖSCH 1969, DUNKERLEY 1971).

HIRSCH (1959) showed that the frequency of backache is decreasing after the age of 50 years, when structural changes in the disc is increasingly more common, and disappears when the disc is completely degenerated. A similar correlation between the incidence of low back pain and age was found by HORAL (1969) and HAKELIUS (1971).

RELIEF OF SCIATIC PAIN

This report

The criteria most suitable for classifying the result of the lumbar disc operation may be grouped as follows:

The effect on 1. sciatic pain
2. low back pain
3. physiological functions
4. postoperative employment, social functions, and activities of daily living

Only information about the postoperative course of sciatica and low back pain was classified and studied for this analysis.

The total number of operations in this part of the analysis is 2,503 as the result of operation was not assessed in one patient, who died from a pulmonary embolism less than 24 hours after the operation.

The assessment of postoperative sciatic pain was based on the latest available follow-up examination within six months after the operation. Information about the course of sciatic pain, as reported in the medical records, later than six months after the operation was disregarded.

The results were classified as follows:

- complete relief of sciatic pain,
- partial relief of sciatic pain,
- no relief of sciatic pain,
- poor, *i.e.* a notable deterioration immediately after the operation.

The surgical results, as judged by the relief of sciatic pain, are specified in Table 14. Complete relief was reported by 76.9 per cent of all patient, partial relief by 17.6 per cent, no relief by 5.0 per cent, and in 12 patients or 0.5 per cent the pain apparently increased in connection with the operation.

Table 14. The relief of sciatic pain by sex in all operations (Frequencies and percentage distribution)

Sex	Total number of operations	Relief of sciatic pain: Complete relief no.	%	Partial relief no.	%	No relief no.	%	Poor no.	%
Females	741	576	77.7	127	17.1	33	4.5	5	0.7
Males	1 762	1 350	76.6	313	17.8	92	5.2	7	0.4
Total:	2 503	1 926	76.9	440	17.6	125	5.0	12	0.5

A longitudinal study of the series H.I-II shows that the rate of complete relief of sciatica increased with high significance during the period 1951-66 (X^2=49.496***, df=7).

There was no significant sex difference in relief of sciatica (X^2=0.501, df=2). Neither was the sex difference significant when these rates were studied separately in patients with complete herniations (X^2=1.880, df=1) and incomplete herniations (X^2=2.134, df=1).

The rate of unsatisfactory results, *i.e.* the subgroups »no relief» and »poor» considered together, was 5.2 per cent in women and 5.6 per cent in men. This difference is not significant (X^2=0.347, df=1).

The correlation between relief of sciatica and age at operation is specified in Table 15 (Fig. 23). In the total material the rate of complete relief is decreasing significantly with age (X^2=32.214***, df=4).

Table 15. The relief of sciatic pain by age at operation (Frequencies and percentage distribution)
(Frequencies and percentage distribution)

Age groups	Total number of operations	Relief of sciatic pain							
		Complete relief		Partial relief		No relief		Poor	
		no.	%	no.	%	no.	%	no.	%
15-19	30	26	86.6	2	6.7	0	0.0	2	6.7
20-29	292	221	75.7	50	17.1	21	7.2	0	0.0
30-39	834	667	80.0	137	16.4	30	3.6	0	0.0
40-49	859	677	78.8	141	16.4	36	4.2	5	0.6
50-59	395	281	71.1	81	20.5	30	7.6	3	0.8
60-69	89	52	58.4	29	32.6	7	7.9	1	1.1
70-74	4	2	(50.0)	0	(0.0)	1	(25.0)	1	(25.0)
Total:	2 503	1 926	76.9	440	17.6	125	5.0	12	0.5

When the material is further separated by degree of herniation (Fig. 24), the decrease in complete relief of sciatica with age is, however, repeated only in patients with incomplete herniations (X^2=11.102*, df=4), bulging discs and negative explorations (X^2=11.862*, df=4). In the subgroup with complete herniations, the rate of complete relief tends to increase after the age of 60 years, but the difference is not significant (X^2=5.468, df=4).

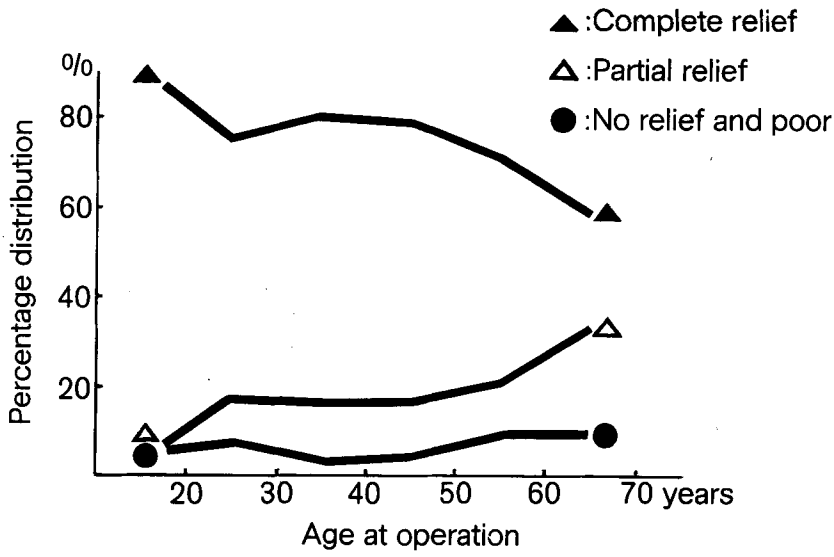

Fig.23. The relief of sciatic pain by age at operation.

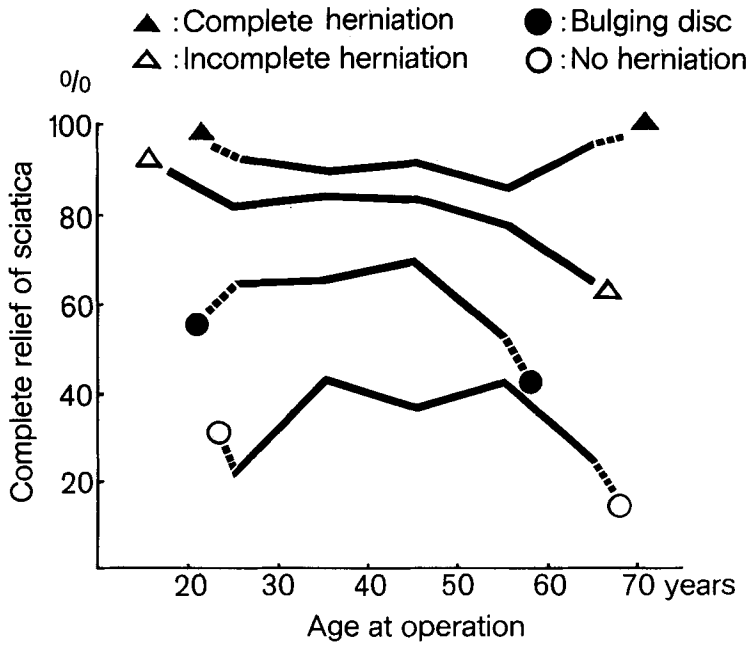

Fig.24. The rate of complete relief of sciatica by age at operation and degree of herniation in the total material.

In Table 16 the relief of sciatica is correlated to the levels of herniation. When all positive operations are considered, the rate of complete relief is 83.3 per cent at the level L5-S1 and 83.7 per cent at the level L4-L5. The difference in relief is not significant when these two levels are compared (X^2=4.017, df=2).

At the level L3-L4 the results apparently tend to be less favorable, but the decrease in relief is still not significant as compared with the two low levels (X^2=2.087, df=2).

Table 16. The relief of sciatic pain by level of herniation (Frequencies and percentage distribution)

Level of herniation	Total number of operations	Relief of sciatic pain: Complete relief		Partial relief		No relief		Poor	
		no.	%	no.	%	no.	%	no.	%
L1 - L3	5	5	(100.0)	0	(0.0)	0	(0.0)	0	(0.0)
L3 - L4	40	30	75.0	7	17.5	3	7.5	0	0.0
L4 - L5	1 023	856	83.7	150	14.6	16	1.6	1	0.1
L5 - S1	1 089	907	83.3	150	13.8	30	2.7	2	0.2
All positive:	2 157	1 798	83.4	307	14.2	49	2.3	3	0.1

When the material is further separated by sex and degree of herniation, there is no significant difference in the rates of complete relief at the two low levels in any of the subgroups.

In Table 17 the relief of sciatica is correlated to the degree of herniation. This correlation is highly significant (X^2=434.476***,

Table 17. The relief of sciatic pain by degree of herniation (Frequencies and percentage distribution)

Degree of herniation	Total number of operations	Relief of sciatic pain: Complete relief		Partial relief		No relief		Poor	
		no.	%	no.	%	no.	%	no.	%
Complete herniation	838	757	90.3	77	9.2	4	0.5	0	0.0
Incomplete herniation	1 104	905	82.0	173	15.7	25	2.3	1	0.09
Bulging disc	215	136	63.3	57	26.5	20	9.3	2	0.9
No herniation	346	128	37.0	133	38.4	76	22.0	9	2.6
Total:	2 503	1 926	76.9	440	17.6	125	5.0	12	0.5

df=3), and the rate of complete relief is improving with high significance between each degree of herniation (Fig. 25).

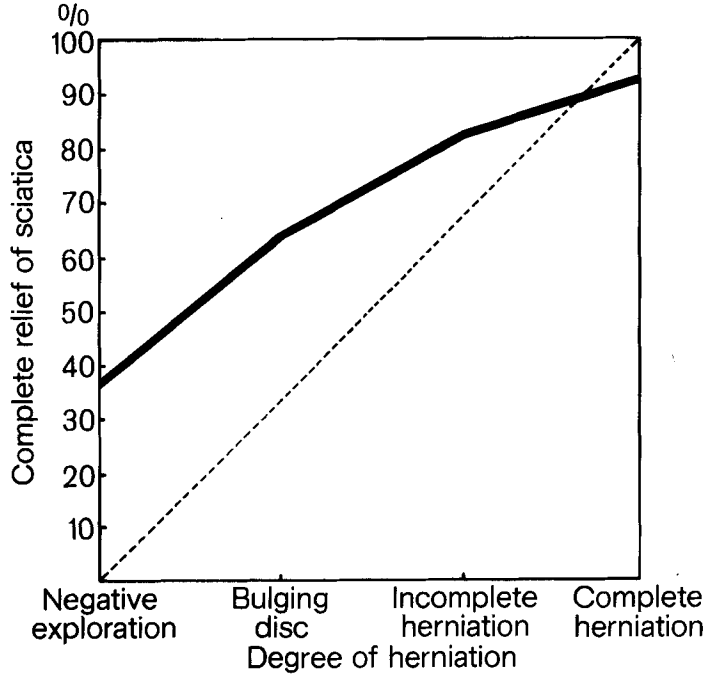

Fig.25. The correlation between the rate of complete relief of sciatica and the degree of herniation in the total material.

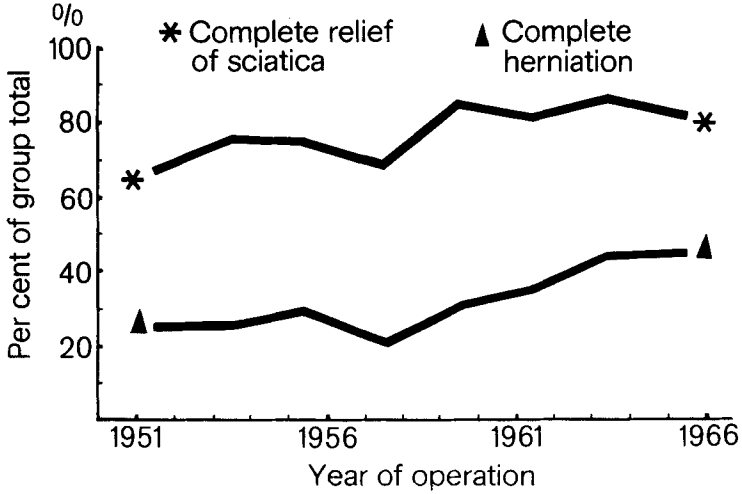

Fig.26. The annual rates of complete herniations and complete relief of sciatic pain in series H.I-II (Härnösand 1951-66)

As shown before, the rate of complete herniations and the rate of complete relief of sciatic pain both increased with high significance during the period 1951-66. Fig. 26 illustrates these rates in a longitudinal study of the series H.I-II. The rates follow a similar pattern during the period.

Comments

i. When the result of operation is assessed by the postoperative relief of sciatic pain, the degree of herniation is found to be the single most important factor for the surgical result. The rate of complete relief of sciatica is increasing - and the rate of unsatisfactory results decreasing - with the degree of herniation. The improvement is highly significant between each of the four degrees of herniation.

ii. On the other hand, the sex of the patient and the level of herniation were found to be variables without significance for the postoperative relief of sciatica in this material.

iii. In the total material the rate of complete relief was decreasing significantly with increasing age, but the unfavorable correlation between results and high age was repeated only by the lower degrees of herniation; in patients with complete herniations, the rate of complete relief was independent of age.

iv. A highly significant increase in the rate of complete relief of sciatica was found in this material during the years 1951-66. A similar, notable increase in the rate of good results was indicated by the survey of previous reports from the last 30 years. This improvement is apparently caused by a corresponding increase in the rate of complete herniations.

v. It seems reasonable to conclude that further improvement of the surgical results depends primarily on a refinement of the preoperative diagnosis and selection of patients with high-grade herniations for operation.

PERSISTENT LOW BACK PAIN

This report

The medical records available for this study were not detailed enough for a complete analysis of the postoperative course of low back symptoms. Instead, the occurrence of »persistent low back pain» at least

one year after the operation was studied separately. In most cases the complaint was serious enough to cause renewed medical attention.

In Tabel 18 the incidence of persistent low back pain is specified by sex and series according to the above-mentioned criteria. The mean incidence was 31.5 per cent in the total material, and there was no significant difference between the series (X^2=3.412, df=2) or the two departments (X^2=1.476, df=1) in this respect.

A longitudinal study of the series H.I-II also confirms that the incidence was fairly constant during the period 1951-66 (X^2=9.106, df=7).

The mean incidence of persistent low back pain was 31.0 per cent in women and 31.8 per cent in men. This sex difference is not significant (X^2=0.127, df=1).

Table 18. The incidence of persistent low back pain by sex and series (Frequencies and per cent of group total)

Series	Total number of operations	Persistent low back pain					
		Females		Males		Both sexes	
		no.	%	no.	%	no.	%
H.I	1 122	105	34.3	258	31.6	363	32.4
H.II	947	86	27.3	193	30.5	279	29.5
Umeå	435	39	32.5	109	34.6	148	34.0
Total:	2 504	230	31.0	560	31.8	790	31.5

The correlation between persistent low back pain and age at operation is shown in Fig. 27. The incidence is increasing to the age of 55 years and then tends to decrease again. This correlation between low back pain and age is significant (X^2=19.283**, df=5).

In Table 19 the patients are further separated by degree of herniation. In the subgroup with complete herniations the incidence of persistent low back pain was 24.8 per cent, in incomplete herniations 26.0 per cent, in bulging discs 45.6 per cent, and in negative explorations 56.8 per cent. This is a highly significant decrease in the incidence with increasing degree of herniation (X^2=155.160***, df=3). There is, however, no significant difference in the incidence when complete and incomplete herniations are compared (X^2=0.347, df=1).

Moreover, the incidence of persistent low back pain was not significantly correlated to age at operation in these patients with true herniations (X^2=7.238, df=5). The subgroup with bulging discs had a

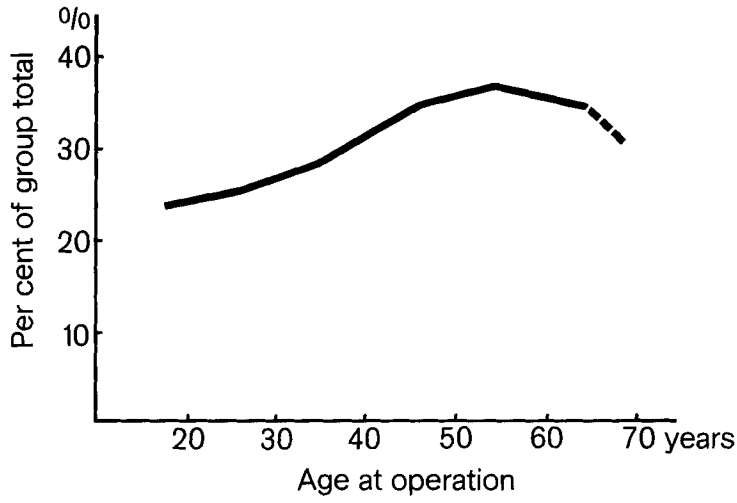

Fig.27. The incidence of persistent low back pain by age at operation.

higher incidence and a more pronounced increase with age, but the correlation was not significant (X^2=3.823, df=3). Negative explorations had the highest incidence and an almost significant correlation to age (X^2=10.011*, df=4).

Table 19. The incidence of persistent low back pain (LBP) by age at operation and degree of herniation (Frequencies and per cent of group total)

Age groups	Total number of operations	Degree of herniation: Complete herniation LBP no.	%	Incomplete herniation LBP no.	%	Bulging disc LBP no.	%	No herniation LBP no.	%	Total LBP no.	%
15-19	30	1	(25.0)	4	19.0	1	(50.0)	1	(33.3)	7	23.3
20-29	292	13	15.7	34	23.1	10	40.0	16	43.2	73	25.0
30-39	834	67	24.1	97	24.4	25	37.3	48	52.7	237	28.4
40-49	859	78	25.3	102	28.2	40	52.6	75	66.4	295	34.3
50-59	396	43	30.5	38	27.3	20	50.0	45	59.2	146	36.9
60-69	89	6	20.0	12	32.4	2	(40.0)	11	44.0	31	34.8
70-74	4	0	(0.0)	0	-	0	-	1	(50.0)	1	(25.0)
Total:	2 504	208	24.8	287	26.0	98	45.6	197	56.8	790	31.5

In Tabel 20 the incidence of persistent low back pain is correlated to the level and the degree of herniation.

When all positive operations are considered, the incidence seems to increase with the level of herniation in the cranial direction, but this correlation is not significant (X^2=3.225, df=2). The trend is repeated in all the subgroups when the material is separated by degree of herniation, but still without significance (X^2=6.229, df=4).

Table 20. The incidence of persistent low back pain (LBP) by level and degree of herniation (Frequencies and per cent of group total)

Level of herniation	Total number of operations	Degree of herniation: Complete herniation LBP no.	%	Incomplete herniation LBP no.	%	Bulging disc LBP no.	%	All positive operations LBP no.	%
L1 - L4	45	5	26.3	4	20.0	5	(83.3)	14	31.1
L4 - L5	1 023	111	26.9	144	28.0	43	44.8	298	29.1
L5 - S1	1 089	92	22.6	139	24.4	50	44.2	281	25.8
Total:	2 157	208	24.8	287	26.0	98	45.6	593	27.5

The correlation between relief of sciatic pain and persistent low back pain is analysed in Table 21. The incidence of low back pain was 21.8 per cent in patients with complete relief of sciatica, 59.1 per cent in the subgroup with partial relief, and 80.3 per cent in those with unsatisfactory relief. This correlation is highly significant (X^2=389.825***, df=2). There is no significant sex difference in these distributions (X^2=1.654, df=2).

Table 21. The correlation between relief of sciatic pain and persistent low back pain (Frequencies and per cent of group total)

Relief of sciatic pain	Total number of operations F	M	F + M	Persistent low back pain: Females no.	%	Males no.	%	Both sexes no.	%
Complete relief	576	1 350	1 926	130	22.6	290	21.5	420	21.8
Partial relief	127	313	440	72	56.7	188	60.1	260	59.1
No relief or poor	38	99	137	28	73.7	82	82.8	110	80.3
Total:	741	1 762	2 503	230	31.0	560	31.8	790	31.6

Complete relief of pain. Complete relief of both sciatica and low back pain was achieved in 60.2 per cent of all patients. This rate was the same in women and men.

Comments

For practical reasons the occurrence of postoperative low back pain was studied by a method that may no disclose the true frequencies. The validity of the information should, however, benefit from the fact that the counties represented in this study have only one orthopaedic centre each, and almost any patient with prolonged low back-complaints claiming treatment, sickness-allowance, vocational rehabilitation, or disability pension is referred to these departments for examination and report of experts.

i. According to the present study, persistent low back pain may be expected in more than 30 per cent of all disc operations. This estimation is in agreement with most other reports on the late results of disc operation.

ii. In general, the incidence of persistent low back pain was found to be a variable with more constant features than relief of sciatic pain. There was no significant change in the incidence during the period 1951-66, and no significant differences between the series, the departments , the sexes, or the levels.

iii. The degree of herniation was the single most important factor for the result of operation, also where low back pain is considered. In negative explorations and bulging discs the incidence of persistent low back pain increased to the age of 45 years and then decreased again. Complete and incomplete herniations were, however, followed by the same incidence, approximately 25 per cent, and an insignificant increase with age. On these points persistent low back pain differs from relief of sciatic pain.

CHAPTER VIII
COMPLICATIONS

There were no fatal complications during the operations and no cases of damage to abdominal vessels or vicera in the present series.

Surgical lesion to the dura was reported in 41 casés or 1.6 per cent of the operations, but only one of these patients developed a permanent liquor fistula which required additional surgery. Root lesion was reported in 12 cases or 0.5 per cent, and severe hemorrhage - verified by the recorded blood pressure, pulse rate, and therapeutic measures - occurred during the operation in 111 cases or 4.4 per cent.

Mortality. In a survey of 53 previous reports with a total of 22,888 operations, the total operative and postoperative mortality was 0.3 per cent (App.table 16). During the last 30 years this mean rate decreased from 0.4 to 0.2 per cent. Pulmonary embolism and postoperative infections were most frequently reported as the cause of death.

In the present series the mortality was 0.1 per cent as postoperative death was associated with the operation in 3 cases. Two of these patients died from pulmonary embolism, 1 day and 22 days respectively after the operation. The third patient died in another hospital 105 days after the operation in a state of general sepsis. This was probably a late complication to the operation as a lumbar epidural abscess was found at the autopsy.

Cauda equina syndromes. Postoperative cauda equina syndromes developed in five patients or 0.2 per cent. In two cases the complication was mild and the patients recovered completely within three months. The other three patients had severe symptoms with bilateral motor weakness and disturbance of bowel and bladder functions. These patients were followed for several years and recovered slowly and partially to a permanent state of disablement that justified pension. As the majority in this material, these five operations were performed under spinal anaesthesia.

Thrombo-embolism. The mean rate of postoperative thrombo-embolism was 1.7 per cent in 13 previous reports with a total of 6,385 operations. (App.table 17). The range was wide in this survey as might be expected in view of the difficulty to establish a correct

clinical diagnosis of these complications (*e.g.* ARNOLDI 1967, BRODELIUS *et al.* 1970).

In the present material postoperative thrombosis was observed in 26 cases or 1.0 per cent. Pulmonary embolism was diagnosed in 11 of these patients and the course was fatal in two.

In 22 cases the thrombosis was diagnosed within 4 to 12 days after the operation; the others occurred 1, 17, 56 and 60 days after the operation. The two late cases belonged to the small group of 22 fusions contained in this material.

Postoperative wound infection. The mean rate of wound infection in 31 previous reports with a total of 10,104 operations was 2.9 per cent (App.table 18). In this survey, which includes all degrees of infection, the mean rate decreased from 4.1 to 2.2 per cent during the last 30 years.

In this material moderate infections occurred in 3.2 per cent and severe infections in 0.6 per cent.

A longitudinal study of the moderate and severe wound infections in series H.I and H.II shows a highly significant decrease in the annual rate from approximately 8 to less than 2 per cent during the period 1951-66 (X^2=49.679***, df=7).

Pyogenic spondylitis. Frank postoperative spondylitis occurred in two cases. Both the patients recovered completely after a prolonged course with severe clinical symptoms.

In one of these patients, a man of 60 years with diabetes mellitus and rheumatoid arthritis, a retroperitoneal abscess was drained five months after the disc operation and staphylococcus albus cultivated from the pus.

Postoperative discitis. The medical records were screened for all signs and symptoms suggesting postoperative discitis or low-grade infection of the intervertebral space and suspected cases retained for a separate study. In a preliminary survey of series H.I the incidence of this complication was 2 per cent (SPANGFORT, 1964).

SUMMARY

This report presents selected parts of the results achieved by a computer-aided analysis of 2.504 consecutive lumbar disc operations performed in Sweden during the years 1951-66.

The material

In the total material, 90.7 per cent of the operations were true 1st operations, 8.3 per cent true 2nd operations, and 0.8 per cent true 3rd operations. Two patients had four disc operations.

The total sex distribution was 29.6 per cent women and 70.4 per cent men. In 52 previous reports, the corresponding rates were 33.7 per cent women and 66.3 per cent men.

The total mean age at operation was 40.8 years and the range 15-74 years. In women the mean age was 41.0 years, in men 40.7 years.This difference is not significant. The mean age increased from approximately 38 to 44 years during the period 1951-66, and the trend was apparently rather constant without notable sex difference.

In a similar study of 30 previous reports, the mean age was 39.2 years, women were usually a little younger than men, and the mean age increased from 38.3 to 40.4 years during the last 30 years.

The postoperative period of observation was less than 15 days in 3.0 per cent of the patients, between 15 and 60 days in 17.2 per cent, and more than 60 days in 79.8 per cent.

The mean duration of sciatic pain before the operation was 3.3 years, and the mean duration of low back pain 5.6 years. In both cases the duration was a little shorter in women than in men.

Radiology

A complete analysis of the radiological material was beyond the purpose of this study.

A total of 498 operations or 19.9 per cent of all operations were performed without myelography. In this group the rate of negative explorations was low, 5.7 per cent, in the age group 15-49 years and then increased with high significance.

Pneumomyelography was used in 72 cases. In the remaining 1.934 cases the patients were examined by lumbar myelography with water-soluble iodine contrast before the operation.

The incidence of false negative myelograms was largely independent of age, while the rate of false positive myelograms increased with high significance after the age of 57 years. It is assumed that the myelographic examination maintains a high degree of diagnostic value for nearly ten years longer than the general, clinical syndromes.

The rate of correct myelographic predictions was significantly higher at the level L4-L5 than at the level L5-S1.

Lasègue's sign

This sign was positive in 95.7 per cent of all patients. The mean rate in 11 previous reports was 91.9 per cent.

Women had a lower incidence than men, the sex difference was significant only when all women and all men were compared, but the lower female rate was repeated in all subgroups and may represent a physiological sex difference in the reaction to straight-leg raising.

The incidence of the sign decreased with high significance with age, and this decrease was also repeated in all subgroups. In spite of this, the diagnostic value of the sign is probably increasing with age, as the decreasing Lasègue-propensity is followed by an increased diagnostic specificity.

The incidence of the sign increased with the degree of herniation, and the correlation was highly significant.

The incidence was higher at the two low levels than at the high lumbar levels, and the difference was highly significant. There was no significant difference when the two low levels were compared.

The crossed Lasègue's sign

The total incidence of this sign was 21.6 per cent as compared with 19.1 per cent in 9 previous reports.

Also the incidence of this sign was lower in women than in men, but an almost significant sex difference was confirmed statistically only in positive operations.

The incidence of the sign decreased with age, and the correlation was highly significant.

The highest rate of the crossed sign was constantly found at the level L4-L5, but the difference between the two low levels was not significant.

The incidence of the crossed sign was correlated to the degree of herniation with high significance. It appears to be less sensitive and more specific for the preoperative diagnosis of disc herniation than the ipsilateral sign.

The crossed Lasègue was followed by a higher incidence of complete herniations, 42.0 per cent, than any other single neurological sign.

Ankle reflex and paresis

In this section the subgroups with monosymptomatic impairment of the ankle reflex, monosymptomatic paresis of dorsiflexion of the foot, concomitant signs, and absence of neurological signs were analysed. There were no significant sex differences in these subgroups.

The analysis disclosed a series of characteristic patterns when the neurological signs were correlated to the age at operation and the level of herniation. These patterns are probably best explained by the fact that the process of disc herniation tends to begin at the lumbo-sacral level and proceed in the cranial direction with age.

It is concluded that a considerable improvement may be expected in the accuracy of the diagnosis if the age of the patient is considered in the preoperative judgment of the neurological signs.

The knee reflex

Impairment of the knee reflex was recorded in 4.2 per cent of the patients. In 20 previous reports the incidence was 8.4 per cent.

The incidence of this sign was high in the juveniles, low in the younger

patients, and then increased constantly with age. The sign was monosymptomatic in one third of the patients.

The study confirms that although 50 per cent of the patients with herniations at the level L3-L4 have impairment of the knee reflex, the sign is of limited value for the prediction of the level of herniation as it is more often associated with herniations at the two low levels.

The cauda equina syndrome

The total incidence was 1.2 per cent in this material and 2.4 per cent in 31 previous reports.

The study does not suggest any notable difference in sex distribution or age at operation when these patients are compared with complete disc series.

In most cases the offending herniation was located at one of the two low levels, but the rate of high lumbar herniations was significantly increased in patients with cauda equina syndromes.

The level of herniation

In previous reports the proportion of L4-L5 herniations increased and L5-S1 herniations decreased during the last 30 years. A similar trend was hardly discernible in the present material.

When all positive operations were considered, there was no significant sex difference in the distribution of herniations at the two low levels.

A correlation of the mean age at operation to the level of herniation showed that the process of disc herniation tends to begin at the lumbo-sacral level and proceed in the cranial direction with age. The correlation was highly significant and the rule was confirmed by further study of the correlation between age groups and level of herniation.

Juvenile patients, however, seem to represent an exception from this rule, as they have a high rate of incomplete herniations at the level L4-L5.

The degree of herniation

The total mean rate of complete herniations was 33.5 per cent in this material and 35.7 per cent in 15 previous reports. The rate of negative explorations was 13.8 per cent in this material and 9.2 per cent in 44 previous reports.

There was no significant sex difference in the degree of herniation in this material.

The rate of complete herniations increased with high significance during the period 1951-66. A similar trend was found in previous reports from the last 30 years.

Incomplete herniations occurred at an earlier age than complete herniations. The difference was highly significant.

For patients with complete herniations, the difference in mean age between the two low levels was 4.5 years. The difference was highly significant.

For patients with incomplete herniations, the difference in mean age between the two low levels was 2.7 years. This was also a highly significant difference, although this subgroup contained an unexpected high number of juveniles with herniations at the level L4-L5.

In the subgroup with bulging discs, the difference between the two low levels was 1.3 years and not significant.

The incidence of negative explorations increased with age, the increase was highly significant and most pronounced after the age of 50 years.

In this material the rate of complete herniations increased in the cranial direction, but the correlation was not significant.

The result of operation

When the result of operation was assessed by the relief of sciatica, the degree of herniation was the single most important factor for the surgical result. The improvement was highly significant between each of the four degrees of herniation.

The sex of the patient and the level of herniation were variables without significance for the relief of sciatica.

The rate of complete relief decreased significantly with age, but the unfavorable correlation between results and high age was repeated only by the lower degrees of herniation; in patients with complete herniations, the rate of complete relief was independent of the age.

The rate of complete relief increased with high significance during the period 1951-66, and a similar trend appeared in previous reports from the last 30 years. This improvement is apparently due to a corresponding increase in the rate of complete herniations.

The total rate of persistent low back pain was 31.5 per cent. This estimation is in agreement with most other reports.

In general, the incidence of persistent low back pain was a variable with more constant features than relief of sciatica. There was no significant change in the incidence during the years 1951-66, and no significant difference between the series, the departments, the sexes, or the levels.

In the total material, the incidence of low back pain increased to the age of 55 years and then tended to decrease again. The correlation between low back pain and age was significant.

The degree of herniation was the single most important factor for the incidence of persistent low back pain. Complete and incomplete herniations were both followed by an incidence of approximately 25 per cent and an insignificant increase with age. In patients with bulging discs the incidence was 45.6 per cent, in negative explorations 56.8 per cent, and in these two subgroups the incidence increased to the age of 45 years and then decreased again. The correlation to age was almost significant in negative explorations.

According to the criteria applied in this study, complete relief of both sciatica and low back pain was achieved in 60.2 per cent of all the patients. This rate was the same in women and men.

Complications

There were no fatal complications during the operations and no damage to abdominal vessels or vicera in this material.

The postoperative mortality was 0.1 per cent. In 53 previous reports the total mortality was 0.3 per cent, and this rate decreased from 0.4 to 0.2 per cent during the last 30 years.

Postoperative cauda equina syndromes developed in five patients, two of these recovered completely within three months.

The rate of thrombo-embolism was 1.0 per cent in this material and 1.7 per cent in 13 previous reports.

Postoperative wound infections of moderate degree occurred in 3.2 per cent and severe wound infections in 0.6 per cent. The incidence of wound infections decreased with high significance during the period 1951-66. In 31 previous reports the mean rate of wound infections was 2.9 per cent, and the rate decreased from 4.1 per cent to 2.2 per cent the last 30 years.

Frank postoperative spondylitis occurred in two patients. They both recovered completely after a prolonged course.

The rate of postoperative discitis was approximately 2 per cent in a preliminary study of the first 1.122 operations of this material.

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APPENDIX

Tabulated surveys of 160 previous reports

Table 1. The sex distribution in previous reports

Author	Year	Number of operations	Females		Males	
			no.	%	no.	%
Barr	1937	40	5	12.5	35	87.5
Malmros	1942	100	37	37.0	63	63.0
DeF. Smith et al.	1944	100	45	45.0	55	55.0
Grant	1944	150	63	42.0	87	58.0
Jelsma	1944	150	44	29.3	106	70.7
Peyton & Levin	1944	65	18	27.7	47	72.3
Yaskin & Finkelstein	1944	50	19	38.0	31	62.0
Lindgren	1945	165	44	26.7	121	73.3
Poppen	1945	400	128	32.0	272	68.0
Petit-Dutaillis & de Sèze	1945	50	13	26.0	37	74.0
Lenhard	1947	843	277	33.0	566	67.0
Love	1947	1 217	363	29.8	854	70.2
Peyton & Simmons	1947	80	20	25.0	60	75.0
Falconer et al.	1948b	100	27	27.0	73	73.0
Grant et al.	1948	95	24	25.3	71	74.7
Lyerly & Grizzard	1948	122	39	32.0	83	68.0
Waris	1948	374	106	28.3	268	71.7
Rövig	1949	100	30	30.0	70	70.0
Shinners & Hamby	1949	359	113	31.5	246	68.5
Spurling & Grantham	1949	378	121	32.0	257	68.0
Busch et al.	1950	1 000	463	46.3	537	53.7
Odell et al.	1950	310	119	38.4	191	61.6
Alfred	1951	130	37	28.5	93	71.5
Bragdon & Shafer	1951	519	122	23.5	397	76.5
O'Connell	1951	500	170	34.0	330	66.0
Pais & Picchio	1951	879	332	36.6	547	63.4
Eyre-Brook	1952	117	50	42.7	67	57.3
Ross & Jelsma	1952	366	138	37.7	228	62.3
Fernström	1956	171	62	36.3	109	63.7
Knutsson & Wiberg	1958	251	117	46.6	134	53.4
Daum et al.	1959	250	88	35.2	162	64.8
Lansche & Ford	1960	660	213	32.2	447	67.8
Wilson	1960	460	172	37.5	288	62.5
Yale	1960	136	48	35.3	88	64.7
Bauchhenss	1961	136	50	36.8	86	63.2
Gurdjian et al.	1961	1 176	406	34.5	770	65.5
Söderberg & Sjöberg	1961	241	84	34.9	157	65.1
Day & Hinchey	1962	195	50	25.6	145	74.4

(cont.)

(Table 1 cont.)

Author	Year	Number of operations	Females		Males	
			no.	%	no.	%
Wiig	1962	100	30	30.0	70	70.0
Brown & Pont	1963	570	158	27.7	412	72.3
Dahlgren	1963	41	16	39.0	25	61.0
Hirsch & Nachemson	1963	232	85	36.6	147	63.4
Lowry	1963	100	25	25.0	75	75.0
Knighton & Hitselberger	1964	294	88	29.9	206	70.1
Lombardi & Passerini	1964	541	193	35.5	348	64.5
Thys et al.	1964	72	14	19.4	58	80.6
Robinson	1965	500	153	30.6	347	69.4
Andersson & Carlsson	1966	372	154	41.4	218	58.6
Slepian	1966	267	85	31.8	182	68.2
Goodsell	1967	402	100	24.9	302	75.1
Marshall & Schorstein	1968	320	125	39.1	195	60.9
Hakelius	1970	166	53	31.9	113	68.1
Total:		16 412	5 536	33.7	10 876	66.3

Table 2. The mean age at operation

Author	Year	Number of operations	Age at operation	
			Mean (years)	Range (years)
Barr	1937	40	37.0	20-58
Malmros	1942	100	38.8	17-63
DeF. Smith et al.	1944	100	37.0	16-70
Peyton & Levin	1944	65	38.4	17-64
Yaskin & Finkelstein	1944	50	39.5	23-64
Petit-Dutaillis & de Sèze	1945	50	39.8	
Love	1947	1 217	39.4	16-68
Lyerly & Grizzard	1948	122	39.8	
Waris	1948	374	37.8	20-66
Echols	1949	101	38.1	17-59
Rövig	1949	100	34.6	18-57
Busch et al.	1950	1 000	37.4	
Alfred	1951	130	38.7	22-63
O'Connell	1951	500	34.5	16-58
Aitken	1952	200	40.4	
Ross & Jelsma	1952	366	39.3	15-70
Fernström	1956	171	40.7	11-

(cont.)

(Table 2 cont.)

Author	Year	Number of operations	Age at operation	
			Mean (years)	Range (years)
Heppner & Moshammer	1956	152	41.3	19-70
Knutsson & Wiberg	1958	251	39.9	16-68
Lansche & Ford	1960	660	41.5	17-76
Gurdjian et al.	1961	1 176	41.3	17-
Day & Hinchey	1962	195	41.5	20-65
DePalma & Gillespy	1962	83	40.0	18-68
Wiig	1962	100	39.2	21-65
Hirsch & Nachemson	1963	232	42.0	
Lowry	1963	100	34.0	19-53
Howorth	1964	112	39.0	19-72
Knighton & Hitselberger	1964	294	39.0	17-72
Lombardi & Passerini	1964	541	42.0	16-
Robinson	1965	500	38.1	13-
Total:		9 082	39.2	11-76

Summary

Year of reports	Number of reports	Number of operations	Mean age at operation
1937	1	40	37.0
1941-50	11	3 279	38.3
1951-60	8	2 430	39.3
1961-70	10	3 333	40.4
Total:	30	9 082	39.2

Table 3. The mean duration of preoperative symptoms

Author	Year	Number of operations	Mean duration of preoperative symptoms	
			Reported	Approximated (years)
Friberg	1941	44	64.7 months	5.4
Grant	1944	150	2 1/4 years	2.3
Jelsma	1944	150	3 years	3.0
Yaskin & Finkelstein	1944	50	4.3 years	4.3
Friberg & Hirsch	1946	41	4 1/2 years	4.5
Campbell & Whitfield	1947	122	3 1/2,4 3/4,3 1/4 y.	3.8
Rövig	1949	100	40 months	3.3
Begg & Falconer	1949	100	3 y.2 m./6 y.	5.5
Alfred	1951	130	3 y. 3 m.	3.3
Padula & Keys	1952	114	3.8 years	3.8
Heppner & Moshammer	1956	105	4 y. 2 m.	4.2
Reynolds et al.	1959	113	4.7 years	4.7
DePalma & Gillespy	1962	83	4 y. 4 m.	4.3
Changchien	1963	27	3 years	3.0
Dunkerley	1971	57	3 1/2 years	3.5
Total:		1 386		3.8

Table 4. The preoperative incidence of Lasègue's sign in positive operations

Author	Year	Number of positive operations	Positive Lasègue's sign	
			no.	%
Craigh & Walsh	1941	285	231	81.1
Friberg	1941	44	41	93.2
Malmros	1942	90	84	93.3
ver Brugghen	1943	59	54	91.5
DeF. Smith et al.	1944	100	70	70.0
Poppen	1945	400	360	90.0
Peyton & Simmons	1947	80	75	94.0
Lindgren	1949	500	480	96.0
O'' Connell	1951	500	495	99.0
Ford et al.	1952	96	91	94.8
Decker & Shapiro	1957	279	254	91.0
Total:		2 433	2 235	91.9

Table 5. The preoperative incidence of crossed Lasègue's sign (all operations)

Author	Year	Number of operations	Crossed Lasègue	
			no.	%
Petit-Dutaillis & de Sèze	1945	50	11	22.0
Peyton & Simmons	1947	90	14	15.6
Waris	1948	374	32	8.6
Woodhall & Hayes	1950	304	101	33.2
Knutsson	1961	206	43	20.9
Brown & Pont	1963	485	55	11.3
Changchien	1963	27	8	29.6
Thys et al.	1964	72	31	43.1
Hakelius	1970	165	43	26.1
Total:		1 773	338	19.1

Table 6. The incidence of lumbar herniations without neurological signs (apart from monosymptomatic sensory changes and Lasègue's sign)

Author	Year	Number of operations	Herniations without neurological signs	
			no.	%
Love & Walsh	1943	285	43	15.1
Campbell & Whitfield	1947	122	15	12.3
Young	1947	202	79	39.1
Ståhl	1949	290	25	8.6
Friberg & Hult	1950	218	33	15.1
Aitken	1952	165	54	32.7
Kryger	1958	60	11	18.3
Gottschalck & Höjgaard	1962	604	114	18.9
Wiig	1962	100	20	20.0
Fraser	1966	67	12	17.9
Total:		2 113	406	19.2

Table 7. The incidence of patients with impaired knee reflex

Author	Year	Number of operations	Impairment of the knee reflex	
			no.	%
Barr	1937	40	0	0.0
Bradford & Spurling	1939	44	4	9.1
Friberg	1941	44	5	11.4
Malmros	1942	90	8	8.9
Wiberg	1943	141	15	10.6
Jelsma	1944	150	45	30.0
Peyton & Levin	1944	65	13	20.0
Yaskin & Finkelstein	1944	50	9	18.0
Peyton & Simmons	1947	85	17	20.0
Lyerly & Grizzard	1948	122	20	16.4
Waris	1948	374	27	7.2
Ståhl	1949	306	15	4.9
O'Connell	1951	500	24	4.8
Leikkonen	1959	242	7	2.9
Palazzo	1960	100	9	9.0
Wilson	1960	460	44	9.6
Gurdjian et al.	1961	1 176	79	6.7
Knutsson	1961	206	34	16.5
Wiig	1962	100	3	3.0
Brown & Pont	1963	527	28	5.3
Total:		4 822	406	8.4

Table 8. The incidences of patients with impaired knee reflex by level of herniation

Author	Year	Level of herniation					
		L3 - L4		L4 - L5		L5 - S1	
		no.	%	no.	%	no.	%
Bradford & Spurling	1939	0/1	0.0	2/21	9.5	1/13	7.7
Friberg	1941	0/2	0.0	5/28	17.9	0/13	0.0
Wiberg	1943	1/3	33.3	7/68	10.3	7/69	10.1
Norlén	1944	2/2	100.0				
Peyton & Simmons	1947	3/6	50.0	3/26	11.5	11/45	24.4
Waris	1948	7/7	100.0	8/129	6.2	9/153	5.9
Ståhl	1949	1/2	50.0	4/121	3.3	7/171	4.1
Busch et al.	1950	2/11	18.2				
Alfred	1951	1/2	50.0	2/48	4.2	0/63	0.0
O'Connell	1951	4/8	50.0	10/198	5.1	7/248	2.8
Zander & Brussatis	1952	7/20	35.0				
Leikkonen	1959	3/9	33.3	2/81	2.5	2/152	1.3
Raaf	1959	7/16	43.8	29/262	11.1	31/349	8.9
Knutsson	1961	3/3	100.0	10/78	12.8	2/66	3.0
Wiig	1962	2/3	66.7	1/46	2.2	0/54	0.0
Aronson & Dunsmore	1963	30/51	58.8				
Brown & Pont	1963	3/14	21.4	10/241	4.1	9/228	3.9
Total:		76/160	47.5	93/1347	6.9	86/1624	5.3

Table 9. The incidence of impaired knee reflex at the level L2-L3

Author	Year	no.	%
Friberg	1941	0/1	0.0
Rasmussen	1956	1/5	20.0
Gurdjian et al.	1961	1/3	33.3
Aronson & Dunsmore	1963	6/18	33.3
Brown & Pont	1963	2/2	100.0
Total:		10/29	34.5

Table 10. The incidence of patients with cauda equina syndromes

Author	Year	Number of operations	Cauda equina syndromes	
			no.	%
Barr	1937	40	6	15.0
Fincher	1939	50	4	8.0
Craig & Walsh	1941	285	14	4.9
Friberg	1941	44	2	4.5
Malmros	1942	90	10	11.1
French & Payne	1944	90	8	8.9
ver Brugghen	1945	300	8	2.7
Petit-Dutaillis & de Sèze	1945	50	8	16.0
Peyton & Simmons	1947	90	2	2.2
Waris	1948	374	5	1.3
Rövig	1949	100	12	12.0
Busch et al.	1950	1 000	20	2.0
O'Connell	1951	500	10	2.0
Eyre-Brook	1952	117	1	0.9
Kuhlendahl & Hensell	1953	750	22	2.9
Heppner & Moshammer	1956	105	3	2.9
Jennett	1956	1 000	25	2.5
Malmros	1956	472	4	0.8
Arseni et al.	1958	2 242	47	2.1
Shephard	1959	139	13	9.4
Mikula et al.	1960	120	6	5.0
Palazzo	1960	100	4	4.0
Pásztor & Juhász	1960	482	21	4.4
Gurdjian et al.	1961	1 176	13	1.1
Söderberg & Sjöberg	1961	241	1	0.4
Brown & Pont	1963	570	8	1.4
Sicard	1963	2 962	21	0.7
Hübner	1965	112	11	9.8
Robinson	1965	500	17	3.4
Scott	1965	155	10	6.5
Knudsen	1967	1 300	35	2.7
Total:		15 556	371	2.4

Summary

Year of reports	Number of reports	Number of operations	Cauda equina syndromes	
			no.	%
1937	1	40	6	15.0
1939	1	50	4	8.0
1941-50	10	2 423	89	3.7
1951-60	11	6 027	156	2.6
1961-70	8	7 016	116	1.7
Total:	31	15 556	371	2.4

Table 11. The level of herniation in patients with cauda equina syndromes

Author	Year	Number of operations	Level of herniation				
			L1-L2	L2-L3	L3-L4	L4-L5	L5-S1
Dandy	1942	1	0	0	0	1	0
French & Payne	1944	8	0	0	1	4	3
ver Brugghen	1945	8	0	0	2	3	3
Petit-Dutaillis & de Sèze	1945	8	0	0	2	3	3
Peyton & Simmons	1947	2	0	0	2	0	0
Black	1948	11	0	0	1	7	3
Waris	1948	5	0	0	0	3	2
Kuhlendahl & Hensell	1953	22	0	1	3	10	8
Fairburn & Stewart	1955	3	0	1	1	0	1
Jennett	1956	26	0	1	3	10	12
McClintock	1960	3	0	0	0	1	2
Pásztor & Juhász	1960	21	0	0	4	10	7
Lyons & Wise	1961	1	0	0	0	1	0
Wilson	1962	1	0	0	0	1	0
Robinson	1965	17	0	0	5	10	2
Scott	1965	10	0	1	0	5	4
Schaeffer	1966	5	0	0	0	4	1
Knudsen	1967	35	0	0	4	13	18
Total:		187	0	4	28	86	69
Percentage distribution:			0.0	2.1	15.0	46.0	36.9

Table 12. The levels of herniation

Author	Year	Number of herniations	Level of herniation				
			L1-L2	L2-L3	L3-L4	L4-L5	L5-S1
			no.	no.	no.	no.	no.
Barr	1937	40	0	1	1	26	12
Macey	1940	96	0	1	8	41	46
Spurling & Grantham	1940	93	0	0	1	52	40
Friberg	1941	44	0	1	2	28	13
Malmros	1942	102	1	0	6	54	41
ver Brugghen	1943	67	0	0	3	24	40
Wiberg	1943	141	0	1	3	68	69
DeF. Smith et al.	1944	103	0	0	1	62	40
Lindgren	1945	126	0	1	2	48	75
Petit-Dutaillis & de Sèze	1945	50	1	1	5	28	15
Aitken & Bradford	1947	97	0	0	3	52	42
Campbell & Whitfield	1947	127	0	0	6	58	63
Peyton & Simmons	1947	80	0	0	6	28	46
Lyerly & Grizzard	1948	125	0	0	7	45	73
Waris	1948	330	0	0	8	145	177
Echols	1949	101	0	0	0	50	51
Ectors	1949	100	0	0	0	35	65
Rövig	1949	105	0	2	5	60	38
Shinners & Hamby	1949	392	0	0	14	155	223
Ståhl	1949	294	0	0	2	121	171
Pais & Picchio	1951	902	1	4	12	520	365
Aitken	1952	158	0	1	12	60	85
Eyre-Brook	1952	103	0	0	2	28	73
Ford et al.	1952	96	0	0	5	46	45
Ross et Jelsma	1952	332	0	0	1	104	227
Törmä	1952	1 500	0	1	24	774	701
Voris	1954	260	2	2	19	136	101
Scuderi & Khedroo	1955	108	0	0	1	55	52
Svaar	1955	164	0	2	4	71	87
Rasmussen	1956	1 405	0	5	27	758	615
Decker & Shapiro	1957	279	0	2	8	103	166
Knutsson & Wiberg	1958	219	0	1	2	82	134
Raaf	1959	638	0	3	16	262	357
Lansche & Ford	1960	704	1	2	39	360	302
Webster & Smiley	1960	120	0	0	3	55	62
Yale	1960	147	0	0	1	59	87
Gurdjian et al.	1961	1 285	0	0	26	635	624
Day & Hinchey	1962	183	0	1	8	87	87
DePalma & Gillespy	1962	86	0	0	0	46	40
Wiig	1962	103	0	0	3	46	54
Borroni & Ciaramella	1963	1 014	0	0	28	731	255
Brown & Pont	1963	487	0	2	16	241	224

(cont)

(Table 12 cont)

Author	Year	Number of herniations	Level of herniation L1-L2 no.	L2-L3 no.	L3-L4 no.	L4-L5 no.	L5-S1 no.
Lowry	1963	100	0	0	0	31	69
Eie	1964	296	0	0	11	174	111
Lombardi & Passerini	1964	626	6	17	41	342	220
Robinson	1965	500	0	1	16	189	294
White	1966	123	0	0	6	47	70
Viernstein et al.	1966	347	0	1	10	191	145
Marshall & Schorstein	1968	337	0	0	6	176	155
Total:		15 235	12	53	430	7 589	7 151
Percentage distribution:			0.1	0.4	2.8	49.8	46.9

Summary

Year of reports	Number of reports	Number of herniations	Level of herniation L1-L2 no.	%	L2-L3 no.	%	L3-L4 no.	%	L4-L5 no.	%	L5-S1 no.	%
1937-40	3	229	0	0.0	2	0.9	10	4.4	119	51.9	98	42.8
1941-50	17	2 384	2	0.1	6	0.2	73	3.1	1 061	44.5	1 242	52.1
1951-60	16	7 135	4	0.1	23	0.3	176	2.4	3 473	48.7	3 459	48.5
1961-70	13	5 487	6	0.1	22	0.4	171	3.1	2 936	53.5	2 352	42.9
Total:	49	15 235	12	0.1	53	0.4	430	2.8	7 589	49.8	7 151	46.9

Table 13. The incidence of complete herniations

Author	Year	Number of operations	Complete herniation	
			no.	%
Grant	1946	200	49	24.5
Sjöquist	1946	450	100	22.2
Peyton & Simmons	1947	90	29	32.2
Waris	1948	374	98	26.2
Crawford et al.	1949	346	142	41.0
Echols	1949	151	21	13.9
Decker & Shapiro	1957	347	99	28.5
Lansche & Ford	1960	704	187	26.6
Palazzo	1960	100	42	42.0
Gurdjian et al.	1961	1 176	636	54.1
Wiig	1962	100	33	33.0
Brown & Pont	1963	570	242	42.5
Genest	1963	100	30	30.0
Goodsell	1967	402	116	28.9
Hakelius	1970	165	57	34.5
Total:		5 275	1 881	35.7

Summary

Year of reports	Number of reports	Number of operations	Complete herniation	
			no.	%
1946-50	6	1 611	439	27.3
1951-70	9	3 664	1 442	39.4
Total:	15	5 275	1 881	35.7

Table 14. The incidence of negative explorations

Author	Year	Number of operations	Negative explorations	
			no.	%
ver Brugghen	1943	75	9	12.0
Jelsma	1944	150	9	6.0
Peyton & Levin	1944	65	10	15.4
Echlin et al.	1946	60	4	6.7
Holmes & Sworn	1946	50	23	46.0
Aitken & Bradford	1947	170	67	39.4
Peyton & Simmons	1947	90	10	11.1
Lyerly & Grizzard	1948	122	3	2.5
Waris	1948	374	44	11.8
Echols & Rehfeldt	1949	151	34	22.5
Ectors	1949	107	7	6.5
Spurling & Grantham	1949	378	30	7.9
Ståhl	1949	306	16	5.2
Alfred	1951	130	14	10.8
Burns & Young	1951	913	81	8.9
O'Connell	1951	518	18	3.5
Pais & Picchio	1951	1 000	94	9.4
Röttgen	1951	500	86	17.2
Aitken	1952	200	35	17.5
Bergsman et al.	1952	142	15	10.6
Eyre-Brook	1952	117	18	15.4
Alpers	1953	354	22	6.2
Guillaume & Janny	1953	1 012	69	6.8
Millikan	1954	349	23	6.6
Scuderi & Khedroo	1955	113	4	3.5
Heppner & Moshammer	1956	105	20	19.0
Malmros	1956	110	10	9.1
Rathke & Heipertz	1956	50	2	4.0
Decker & Shapiro	1957	347	68	19.6
Knutsson & Wiberg	1958	219	32	14.6
Palazzo	1960	100	1	1.0
Wilson	1960	460	26	5.7
Bauchhenss	1961	136	10	7.4
Gurdjian et al.	1961	1 176	25	2.1
Söderberg & Sjöberg	1961	241	8	3.3
Borroni & Ciaramella	1963	1 126	117	10.4
Brown & Pont	1963	570	41	7.2
Genest	1963	100	15	15.0
Howorth	1963	112	8	7.1
Viernstein et al.	1966	344	36	10.5
Marshall & Schorstein	1968	320	16	5.0
MacNab	1968	713	53	7.4
Kondo et al.	1969	225	40	17.8
Hakelius	1970	165	15	9.1
Total:		14 065	1 288	9.2

Summary

Year of reports	Number of reports	Total number of operations	Negative explorations no.	Negative explorations %
1941-50	13	2 098	266	12.7
1951-60	19	6 739	638	9.5
1961-70	12	5 228	384	7.3
Total:	44	14 065	1 288	9.2

Table 15. The incidence of »complete relief of all symptoms»

Author	Year	Number of operations	Complete relief no.	Complete relief %
Malmros	1942	66	44	66.7
Kirstein	1945	25	10	40.0
Grant	1946	200	127	63.5
Aitken & Bradford	1947	170	22	12.9
Lenhard	1947	147	35	23.8
Senning & Sjöqvist	1947	403	225	55.8
Waris	1948	347	142	40.9
Echols	1949	101	47	46.5
Raaf & Berglund	1949	117	50	42.7
Shinners & Hamby	1949	355	167	47.0
Spurling & Grantham	1949	327	131	40.1
Weber	1950	459	179	39.0
O'Connell	1951	443	206	46.5
Wiberg & Ståhl	1951	287	91	31.7
Grantham & Spurling	1953	298	180	60.4
Knutsson	1961	202	106	52.5
Dahlgren	1963	38	22	57.9
Earnest III & Webb	1963	264	145	54.9
Viernstein et al.	1966	344	145	42.2
Marshall & Schorstein	1968	214	147	68.7
Kirchheiner	1969	80	39	48.8
Total:		4 887	2 260	46.2

Summary

Year of reports	Number of reports	Number of operations	Complete relief no.	Complete relief %
1941-50	12	2 717	1 179	43.4
1951-70	9	2 170	1 081	49.8
Total:	21	4 887	2 260	46.2

Table 16. The total mortality in previous reports

Author	Year	Number of operations	Mortality no.	Mortality %
Mixter	1937	65	1	1.5
Bradford & Spurling	1939	60	3	5.0
Fincher	1939	50	0	0.0
Barr & Mixter	1941	130	0	0.0
DeF.Smith et al.	1944	100	0	0.0
Poppen	1945	400	0	0.0
Aitken & Bradford	1947	170	5	2.9
Love	1947	1 217	3	0.2
Peyton & Simmons	1947	90	1	1.1
Senning & Sjöquist	1947	403	0	0.0
Falconer et al.	1948b	100	0	0.0
Lyerly & Grizzard	1948	122	0	0.0
Waris	1948	374	5	1.3
Crawford et al.	1949	346	0	0.0
Echols	1949	151	1	0.7
Rövig	1949	100	0	0.0
Spurling & Grantham	1949	378	1	0.3
Busch et al.	1950	1 200	4	0.3
O'Connell	1950	618	2	0.3
Odell et al.	1950	455	1	0.2
Weber	1950	912	3	0.3
Alfred	1951	130	0	0.0
Röttgen	1951	500	2	0.4
Wiberg & Ståhl	1951	306	1	0.3
Aitken	1952	200	0	0.0
Korhonen & Nummi	1952	77	0	0.0
Padula & Keys	1952	114	2	1.8
Ross & Jelsma	1952	800	1	0.1
Grantham & Spurling	1953	322	2	0.6
Guillaume & Janny	1953	1 012	0	0.0
Miller	1954	1 000	4	0.4
Cloward	1955	427	1	0.8
Heppner & Moshammer	1956	105	0	0.0
Munro	1956	375	3	0.8
Decker & Shapiro	1957	347	0	0.0
Leikkonen	1959	359	5	1.4
Raaf	1959	954	0	0.0
Yale	1960	136	0	0.0
Bauchhenss	1961	136	1	0.7
Gottschalck & Höjgaard	1961	604	2	0.3
Gurdjian et al.	1961	1 176	2	0.2
Klar & Henn	1961	56	1	1.8
Brown & Pont	1963	570	2	0.3
Changchien	1963	27	0	0.0

(cont)

(Table 16 cont)

Author	Year	Number of operations	Mortality no.	%
Genest	1963	100	0	0.0
Hirsch & Nachemson	1963	232	1	0.4
Lowry	1963	500	0	0.0
Sicard	1963	2 962	3	0.1
Eie	1964	288	0	0.0
Shenkin & Haft	1966	536	3	0.6
Slepian	1966	287	1	0.3
Barr et al.	1967	644	2	0.3
Hakelius	1970	165	0	0.0
Total:		22 888	69	0.3

Summary

Year of reports	Number of reports	Number of operations	Mortality no.	%
1937-40	3	175	4	2.3
1941-50	18	7 266	26	0.4
1951-60	17	7 164	21	0.3
1961-70	15	8 283	18	0.2
Total:	53	22 888	69	0.3

Table 17. The incidence of thrombosis and embolism

Author	Year	Number of operations	Thrombo-embolism no.	%
Rövig	1949	100	9	9.0
Weber	1950	912	9	0.9
Eyre-Brook	1952	117	1	0.8
Nachlas	1952	374	4	1.1
Svaar	1955	157	3	1.9
Munro	1956	375	2	0.6
Knutsson & Wiberg	1958	251	3	1.2
Söderberg & Sjöberg	1961	241	3	1.2
Wiig	1962	100	4	4.0
Sicard	1963	2 962	59	2.0
Slepian	1966	287	3	1.0
Viernstein et al.	1966	344	5	1.5
Hakelius	1970	165	2	1.2
Total:		6 385	107	1.7

Table 18. The incidence of postoperative wound infection

Author	Year	Number of operations	Postoperative infections (all degrees)	
			no.	%
Fincher	1939	50	4	8.0
DeF. Smith et al.	1944	100	5	5.0
Aitken & Bradford	1947	170	9	5.3
Peyton & Simmons	1947	90	2	2.2
Senning & Sjöquist	1947	403	16	4.0
Waris	1948	374	29	7.8
Rövig	1949	100	5	5.0
Odell et al.	1950	310	9	2.9
Weber	1950	912	27	3.0
O'Connell	1951	500	15	3.0
Wiberg & Ståhl	1951	306	9	2.9
Aitken	1952	200	5	2.5
Eyre-Brook	1952	117	1	0.9
Nachlas	1952	374	18	4.8
Svaar	1955	157	7	4.5
Munro	1956	375	6	1.6
Knutsson & Wiberg	1958	251	9	3.6
Raaf	1959	954	7	0.7
Reynolds et al.	1959	142	7	4.9
Wilson	1960	460	18	3.9
Yale	1960	136	1	0.7
Bauchhenss	1961	385	3	0.8
Gurdjian et al.	1961	1 176	14	1.2
Söderberg & Sjöberg	1961	241	28	11.6
Wiig	1962	100	3	3.0
Brown & Pont	1963	570	8	1.5
Eie	1964	282	9	3.2
Kallio & Törmä	1965	75	3	4.0
Slepian	1966	287	6	2.0
White	1966	342	4	1.2
Hakelius	1970	165	3	1.8
Total:		10 104	290	2.9

Summary

Year of reports	Number of reports	Number of operations	Postoperative infections (all degrees)	
			no.	%
1939	1	50	4	8.0
1941-50	8	2 459	102	4.1
1951-60	12	3 972	103	2.6
1961-70	10	3 623	81	2.2
Total:	31	10 104	290	2.9