

**Staff Meeting Bulletin**  
**Hospitals of the . . .**  
**University of Minnesota**

**Roentgenologic Diagnosis**  
**of Spinal Cord Lesions**

STAFF MEETING BULLETIN  
HOSPITALS OF THE . . .  
UNIVERSITY OF MINNESOTA

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INDEX

	<u>PAGE</u>
I. LAST WEEK . . . . .	226
II. MOVIE . . . . .	226
III. ABSTRACT	
ROENTGENOLOGIC DIAGNOSIS OF SPINAL CORD LESIONS	
. . . . . Harold O. Peterson . . . . .	226 - 233
ANALYSIS OF UNIVERSITY OF MINNESOTA	
HOSPITALS CASES . . . . .	231
IV. CASE REPORTS	
I. HEMANGIOMA OF THORACIC CORD . . . . .	233 - 234
2. NEUROFIBROMA OF CAUDA EQUINA . . . . .	234
3. POSTERIOR RUPTURE OF NUCLEUS PULPOSUS . . . . .	234 - 235
V. GOSSIP . . . . .	235

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during the school year, October to May, inclusive.

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William A. O'Brien, M.D.

I. LAST WEEK

Date: February 25, 1937

Place: Nurses' Hall  
Recreation Room

Time: 12:15 to 1:20 P.M.

Program: Movie: Color Box  
Kaleidoscope

Abstract: Low Back Pain

Present: 122

Discussion: W. P. Ritchie  
L. G. Rigler  
J. C. McKinley  
C. D. Creevy  
J. C. Litzenberg  
R. E. Boynton

II. MOVIE

Title: The Seeing Eye

Released by: Fox Films

III. ABSTRACT

ROENTGENOLOGIC DIAGNOSIS  
OF SPINAL CORD LESIONS

Harold O. Peterson

"There are but few organs in the human body in which neoplastic disease occurs in a more benign form and the results of surgery are more brilliant than in the spinal cord and its membranes. At the same time there is no organ in which total restoration of function following the removal of the neoplasm is so completely dependent on an early diagnosis" (Mayfield and Spurling). In 1918, Pancoast stated that roentgen examination was of no value in the diagnosis of tumors of the spinal cord. Carman and Davis in 1924 found bony changes on roentgen examination in only 3 out of 119 cases. With the aid of subarachnoid injections of lipiodol,

as proposed by Sicard and Forestier in 1922, and by painstaking examination of the finer bony changes in the spine itself, it is now possible to diagnose and localize almost 100% of all space consuming lesions of the spinal canal.

Symptoms and Neurological Findings  
in Cord Tumors

Pain is usually the initial symptom followed by the development of paresthesias, motor weakness, paralysis and sphincter disturbances. The average duration of these symptoms in one large series of intramedullary tumors reported by Kernohan, Woltman and Adson was 4.9 years and in another series of extramedullary tumors reported by Tamaki, approximately 2 years.

The sensory level is the most valuable of all the neurological findings in determining the segmental level of the tumor. Oftentimes, it rises to the true level of the lesion quite late in the course of the disease however and only after a well advanced paralysis has developed. In tumors involving the cauda equina the sensory level may be particularly misleading. For these reasons the early and accurate roentgenologic examination of suspected cases of cord tumor may be of inestimable value.

Classification

There is no generally accepted pathologic classification of spinal cord tumors. Grossly, they can usually be classified according to their location as belonging to one of three types.

1. Intramedullary: Arising from the substance of the cord itself.
2. Extramedullary-intradural: Arising from the meninges or other structures within the meninges.

3. Extradural: Arising in the soft tissues, bony or cartilaginous tissues outside the dura.

- f. Sarcoma  
g. Fracture  
h. Arthritis

The histopathology of the intramedullary tumors has been well studied by Kernohan, Woltman, and Adson in a group of 51 cases and they have classified them as follows:

Ependymal tumors	21
Spongioblastoma	7
Unipolar spongioblastoma	2
Spongioblastoma multiforme	4
Astroblastoma	2
Oligodendroglioma	2
Medulloblastoma	4
Ganglioneuroma	1
Hemangioblastoma	4
Fibroblastoma	1
Lipoma	1
Tuberculoma	1

A composite classification, taken from the literature, of the extramedullary, intradural lesions and the extradural lesions is as follows:

Extramedullary - Intradural

1. Neurofibroma (fibroblastoma, perineural fibroblastoma)
2. Fibroma
3. Meningioma (endothelioma)
4. Hemangioma
5. Hemangi endothelioma
6. Lymphoblastoma
7. Neuroma
8. Lipoma
9. Dermoid
10. Arachnoiditis

Extradural

1. Neurofibroma
2. Lipoma
3. Extradural cyst
4. Chordoma
5. Sarcoma
6. Lymphoblastoma
7. Metastases
- \*8. Rupture of intervertebral disc (ecchondroma)
9. Diseases of vertebra
  - a. Tuberculosis
  - b. Metastases
  - c. Osteoma
  - d. Giant cell tumor
  - e. Myeloma

\*Posterior Rupture of the Intervertebral Disc

Special mention is given this lesion because it represents a rather recently recognized pathological entity. It consists of a posterior protrusion of the nucleus pulposus and annulus fibrosis of the intervertebral disc into the spinal canal producing compression of the spinal cord or nerve roots. The great majority of the ruptures are located in the lumbar canal and produce symptoms which may be indistinguishable from low back strain, sciatica, sacroiliac disease and occasionally cauda equina tumors. The history is usually that of chronic low back pain with sciatic radiation which does not respond to ordinary conservative measures. There may be paresthesias and very frequently a missing ankle or knee jerk is found on the affected side. The spinal fluid protein usually shows an increase above 40 mgs. per 100 c.c. if the puncture is done close to the involved disc. Ordinary films of the spine may be entirely negative or they may show a narrowed intervertebral space. Quite often there is an absence of the normal lumbar lordosis and a scoliosis is present. A definite diagnosis can always be made after the injection of 5 c.c. of lipiodol into the lumbar canal followed by fluoroscopic and radiographic studies. Laminectomy with removal of the offending nodule produces prompt relief of pain and a very grateful patient. Hampton and Robinson have recently reported on 50 cases of this type proved at operation and a larger series of similar cases have been seen at the Mayo Clinic. The demonstration of this lesion offers a very definite anatomical and pathological explanation for many of the hitherto obscure cases of so-called sciatica, low back pain and sacroiliac disease. The patients, like those with facial neuralgia, are eager to cooperate in order to discover the cause and cure for their pain.

Bony Changes produced by Cord as shown on Roentgenograms

Camp, writing in 1934, states that, since 1930, by giving particular attention to the bony changes he has been able to demonstrate the location of the lesion in 50% of cord tumors without using any contrast substances. (A later statement reduces this figure to 30% in a larger series).

Neurofibromas showed changes in 65%	
Endotheliomas	11
Hemangiomas	33
Ependymal cell gliomas	66
Intramedullary tumors	0
(exclusive of ependymomas)	

These tumors involve bone by pressure erosion and have no special distinguishing characteristics except the neurofibromata which tend to protrude through and thus enlarge the intervertebral foramen. The pedicles usually show the erosion first. The laminae become eroded early but this is oftentimes difficult to see. The intervertebral discs are resistant to pressure erosion.

Elsberg and Dyke have shown that by carefully measuring the interpedicular distance it is possible to localize many tumors in which there is no obvious erosion of the pedicles and in which the widening of the canal cannot be determined except by actual measurement. Twenty-nine of 70 verified cases of intradural and extradural expanding lesions showed a pathological widening of the interpedicular space and 23 of these had no erosion of the pedicles. They also feel this measurement may be of some diagnostic, as well as localizing, value since it occurs infrequently in intradural tumors and frequently in extradural tumors located between the 4th and 9th thoracic vertebrae. It was also found to occur in 2 out of 3 intramedullary tumors which had marked enlargement of the cord. They found that only 4 types of tumors extended over an area to include 3 or 4 vertebrae:

1. Giant tumors of cauda
2. Extra and intradural cysts
3. Extra and intradural lipomas
4. Large intradural venous angioma

Spindle shaped enlargements of the spinal canal can occasionally be seen in the lateral views of the spine of patients with large tumors. In these, the erosion of the posterior margin of the body of the vertebra is an important sign.

Myelography. The Intraspinal Injection of Iodized Oil (Lipiodol)

Sicard and Forestier, in 1921, first introduced lipiodol into the epidural space as a diagnostic procedure. In 1922, they began using subarachnoid injections of lipiodol, a procedure which has since become very widely used and of great diagnostic value in diseases of the spinal cord and its coverings.

Until recent years it was customary to be satisfied merely with the demonstration of the level of a complete or partial subarachnoid block. This type of examination is probably satisfactory when a tumor is definitely known to be present and one is interested only in determining its exact location.

However, in very early lesions without complete block and in such conditions as chronic circumscribed arachnoiditis with adhesions, and posterior rupture of the intervertebral disc, such an examination will frequently be negative or produce a bizarre picture which is erroneously interpreted.

With a satisfactory type of examination, it is very often possible to determine whether the lesion is intramedullary, intradural but extramedullary, or extradural. The intramedullary tumor produces a thinning or absence of the central portion of the lipiodol column leaving two streaks along the sides.



The extramedullary-intradural tumor often shows a characteristic concave defect ("cap formation") in the lipiodol column.



The extradural lesion usually produces a straight or slightly irregular border of the lipiodol which is in contact with the tumor.



Arachnoiditis causes a breaking up of the lipiodol with retention of small amounts which tend to collect in irregular masses. This picture is readily simulated by the use of 500 small quantities of lipiodol.



Posterior rupture of the intervertebral disc produces an almost pathognomonic defect in the lipiodol filled subarachnoid space which is usually characterized by having the shape of a "dog's nose" or "anvil tip" and is usually unilateral.



#### Indications for the Use of Lipiodol

Dandy has stated, "Given a gradually progressing bilateral loss of motor power with spasticity, the burden of proof is on any diagnosis other than cord tumor." If the tumor cannot be accurately localized by neurological and roentgenographic examination, lipiodol should be used. Tumors of the cauda equina are particularly difficult to localize clinically. The absence of chemical and color changes in the spinal fluid or the presence of a normal Queckenstedt response are not contra-indications to the use of lipiodol.

Naffziger states that pain either localized or radiating which does not respond to treatment should be investigated as a possible cord tumor. Sicard and Forestier believe they can detect spinal block by lipiodol earlier than by any other means. Globus and Strauss say that not infrequently multiple sclerosis produces definite sensory levels which may lead to unnecessary exploration. Craig states that the outstanding use for lipiodol is for the confirmation of a suggested tumor of the spinal cord and its greatest abuse is its employment in cases in which a complete examination would have established a diagnosis.

Doughty feels it is better to have a small amount of oil at the bottom of one's caudal sac than to have an unnecessary exploration performed or to carry a tumor that has been overlooked.

#### Site of Injection

Before the prevalence of tilting roentgenographic tables, the cisternal injection was preferable. It carries with it a potential danger, however, and occasionally it is difficult or even impossible to dislodge the lipiodol from the convolutions of the cerebellum. Except for the discomfort to the patient of being placed in a vertical position with the head down, equally good results can be obtained by lumbar injections of the lipiodol. This is especially true of those cases where the lesion is in the lower dorsal, lumbar or sacral areas. Large quantities of lipiodol (5 to 10 c.c.) can be injected into the lumbar canal whereas this is not so feasible in cistern punctures.

#### Amount of Lipiodol

One and one-half to two c.c. has been the usual amount employed in most large clinics. This will usually prove satisfactory when one merely wishes to show the level of a complete block. When the block is not complete as is often the case in small tumors, always in cases of arachnoiditis, and very frequently in cases of posterior rupture of the intervertebral disc, a greater quantity of lipiodol is necessary in order to do an accurate roentgenologic examination. Camp states that no less than 5 c.c. should be used. Odin and Runstrom prefer to use 8 to 10 c.c. of an iodized oil of their own preparation. At the Massachusetts' General Hospital, 5 c.c. is considered essential in determining the presence of a posterior rupture of the intervertebral disc. Most authors prefer to remove spinal fluid in quantity corresponding to the oil injected.

## Reactions to Lipiodol

Practically all authors agree on the immediate reaction produced by the injection of lipiodol into the subarachnoid space. Oftentimes, there is a slight temperature rise in the first 24 hours which may remain elevated for one week. Headache, stiffness and backache are other complaints of varying severity and duration. There is usually an increase in the cell count and globulin of the spinal fluid during the first 10 to 14 days after injection. Occasionally, there is an exacerbation of the already present symptoms which may also occur following simple spinal puncture without the injection of lipiodol. Occasionally, surgeons have noted acute meningeal reactions at operation a short time after lipiodol injections. Sharpe and Peterson report one case in which the oil was encysted with many adhesions and signs of inflammation 5 months after injection. No such picture had been present at the original operation 5 months earlier and the encysted oil was now producing signs of cord compression. Sicard and Forestier had no deleterious effects in many cases observed over a 4-year period. Doughty operated on one case 14 months after lipiodol injection and no adhesions or other abnormalities due to lipiodol were found. Spurling and Mayfield used lipiodol in 22 cases locating the lesion in every instance and without any harmful results attributable to lipiodol. Globus and Strauss used 2 c.c. in cistern injections in 90 cases without bad results and in 25 cases examined 2 years after injection the oil was still movable and showed no signs of adhesions. They performed one autopsy  $3\frac{1}{2}$  months after lipiodol injection and no evidence of irritation was found.

Experimentally on rabbits and dogs, there is definite evidence of the acute reaction produced by iodized oils in the subarachnoid space and in many cases degenerative changes have been seen in the ganglion cells and grey matter with evidence of fat encystment. None of these animals, however, showed any clinical signs before being killed to indicate an impairment in the function of the central nervous system.

It has also been shown that the acute reactions to lipiodol are due to impurities (free fatty acids, iodic acid, hydrogen iodide) which are rapidly absorbed. These impurities increase in amount when the lipiodol is old and begins to turn brown and translucent. After the absorption of these impurities, which requires only a few days, the lipiodol may enter the ventricular system without causing any reaction.

## Other Contrast Media

None have proved successful.

Air has been used but not enough contrast is obtained in the spinal canal.

Iodipin (light iodized oil) is more irritating than lipiodol.

Skiodan (abrodil): rapidly absorbed. Produced a marked reaction in the only patient in which it was tried at the University of Minnesota Hospitals.

Thorotrast: shadows not very dense. Rapidly absorbed. Remains permanently in body.

Iodized sesame oil (Lindblom) is said by the author to be less irritant than lipiodol. Edling and Ingvar say it produces same reaction as lipiodol, however.

Analysis of University of  
Minnesota Hospitals Cases

49 cases suspected of having cord tumor or cord compression.  
32 of these proved by surgery to have pathology present.

9 Intramedullary Tumors

1 Spongioblastoma multiforme (?)  
2 Ependymomas  
3 Hemangioblastomas  
3 Intramedullary tumors (no biopsy)

17 Extramedullary - Intradural lesions

4 Neurofibromas  
2 Meningiomas  
1 Hemangioma  
1 Hemangioendothelioma (??)  
5 Hodgkin's (2 questionable)  
4 Arachnoiditis

6 Extradural lesions

1 Metastasis to spine  
1 Metastasis to epidural space  
1 Tuberculosis of spine  
1 Myeloma  
1 Hemangioendothelioma (??)  
1 Ruptured intervertebral disc

9 Negative Explorations

8 No operation

Roentgenological Findings

A. Bony Changes

There were 24 cases which may be considered true cord tumors in the sense that they produced expanding lesions within the spinal canal. Of these, 9 showed evidences of bone erosion on the plain films or widening of the canal so that the tumor could have been localized without lipiodol. One other case showed marked erosion of the pedicles and bodies of several vertebra and extreme widening of the canal but no operation was performed to determine the type of tumor present.

B. Lipiodol Findings

36 cases had subarachnoid injections of lipiodol.  
22 cases had positive lipiodol findings confirmed at operation.

3 cases had negative lipiodol findings and disease was found at operation; two of these showed arachnoiditis and one showed a large extradural cyst with a tumor mass extending through the dura and arising from the cord.

4 cases lipiodol was broken up suggesting slight obstruction but examination was not satisfactory. These had negative explorations.

3 cases had negative lipiodol findings and negative explorations.

4 cases had negative lipiodol findings and no operation.

From the lipiodol picture, the location of the tumor (whether intramedullary, intradural or extradural) could have been determined in 17 cases. In the remaining 5 cases with obstruction, the lipiodol picture was atypical.

13 cases did not have lipiodol.

4 of these had gross bony changes, 3 of which were confirmed at operation. One not operated.

9 had negative x-ray examinations.

4 of these had pathology at operation.  
3 negative explorations.  
3 no operation.

Of 9 negative explorations, 5 showed the insufficient quantity of lipiodol to be broken up and delayed in its passage but not characteristic of tumor. Two cases were entirely negative and 2

cases did not have lipiodol.

produced have been discussed.

### Conclusions

1. 41 patients at the University of Minnesota Hospitals were operated on for signs of cord tumor or cord compression since 1930.
2. 32 of these showed changes at operation. There were 9 negative explorations.
3. 25 of the 32 were correctly diagnosed on roentgen examination; 3 were missed; 4 had no lipiodol and normal plain films.
4. Of the 9 negative explorations, 5 had confusing lipiodol pictures due to the small amount of lipiodol used; 2 were negative and 2 did not have lipiodol.
5. Bone changes, demonstrable on the roentgenogram, were present in 37.5% of the University of Minnesota Hospital cases and in as high as 50% of cases reported in the literature.
6. The exact localization of cord lesions by clinical means alone may be very difficult, particularly in lesions of the cauda equina.
7. Localization by a complete roentgen examination should be nearly 100% accurate.
8. From the appearance of the lipiodol, it is usually possible to obtain fairly accurate knowledge as to the type of tumor.
9. Posterior rupture of the intervertebral disc is a definite clinical entity which accurately explains some of the hitherto obscure cases of low back pain, sciatica, and sacro-iliac disease.
10. The indications for lipiodol injection, the site to be injected, the amount to be injected, the amount to be used, and the reactions

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#### IV. CASE REPORTS

##### 1. HEMANGIOMA OF THORACIC CORD

, age 68.  
Admitted 4-21-33;  
Discharged 5-28-33.

6- -32 - Patient first noticed  
difficulty in walking which was worse  
in evening and improved slightly after  
resting. Later, he was unable to stand  
with his eyes closed. He noticed  
twitchings in his leg muscles. There  
were occasional knife-like pains in  
the abdomen. On admission, he had been  
in bed 3 weeks, unable to walk.

Neurological examination: Marked weak-  
ness of lower extremities. Abdominal  
reflexes absent. Knee and ankle jerks  
markedly hyperactive. There was a knee  
and ankle clonus, especially marked on  
the right, and a bilaterally positive  
Babinski. It was felt that there was  
a definite superficial sensory level  
below the level of the 8th thoracic  
vertebra.

Spinal puncture revealed a slightly  
positive Queckenstedt; spinal fluid,  
clear; cell count, 1; Nonne and Pandy,  
negative; colloidal gold and Wassermann,  
negative.

X-rays: showed erosion of pedicles of  
7th thoracic vertebra and widening  
of the canal.

Operation

4-29-33 - A saddle like extradural tumor was found at the level of the 6th and 7th thoracic vertebrae which was attached to the nerve roots on either side. There was no attachment to the dura. The anterior and posterior roots of the 7th thoracic nerve were cut on both sides and removed together with the entire tumor.

Microscopic Diagnosis: Hemangioma.

8-10-36 - Having some prostatic difficulties. Otherwise entirely well.

\* \* \*

2. NEUROFIBROMA OF CAUDA EQUINA

, 34 years of age.  
Admitted 10-1-32;  
Discharged 10-22-32.

7-8-32 - Following childbirth on July 4th, she noticed sharp pains in the lumbar region, radiating down the posterior part of the thighs toward the feet. The pain was worse on urination and movement of her body or straining of any type. No sphincter disturbances.

Neurological examination

Left knee jerk almost absent; right knee jerk normal. Ankle jerk on left normal and right was almost absent. Disturbance in sensation found about the anus and both lower extremities two inches below a line parallel with the anterior superior spine and symphysis pubis. Abdominal reflexes normal. There was weakness of the left foot and right leg. Impression: Cauda equina tumor.

Spinal fluid revealed a positive Nonne and Noguchi and 20 cells.

X-ray: Lipiodol injection (cistern puncture, .75 c.c. lipiodol) showed some scattering of lipiodol along the cervical and thoracic spine with a definite complete block at the 1st lumbar showing a tendency to "cap formation."

10-8-32 - Laminectomy revealed an intradural-extramedullary tumor 1.5 x 1" completely filling canal at the upper border of the 2d lumbar. It was

attached to one root which was sectioned and the tumor easily removed. Microscopic diagnosis: Neurofibroma.

6- -33 - Patient was cranking car which was in gear and she received lacerations requiring hospitalization. No complaints referable to the cord tumor.

\* \* \* \*

3. POSTERIOR RUPTURE OF NUCLEUS PULPOSUS

, age 45  
Admitted 10-29-36.

Back Pain

5-27-36 - First seen in Dispensary with pain in the back worse on moving about, dating back to 1932 at which time he was told he had a scoliosis. In 1933, he had an operation for kidney stones but the pain in the back grew progressively worse extending down back of the right leg into the foot. The whole lower extremity seemed paralyzed at times.

Slipped

10-21-36 - He slipped on ice, catching himself before falling, and that night he suffered severe back pain radiating down the legs and the next day developed urinary retention. On admission to the hospital on 10-29-36, he had a saddle anesthesia and anesthesia of the soles of the feet. The ankle jerks were absent. In June, he had been seen by the orthopedic service in the Dispensary and they noticed painful straight leg raising, painful hamstrings, and tensor fascia. Diagnosis: Probable hysteria.

Block

11-5-36 - Lipiodol injection (1 c.c. cisternal puncture) showed a block at the upper border of the 4th lumbar vertebra.

Spinal fluid: Lumbar puncture 11-5-36, showed a total protein of 60 mgs. per 100 c.c. and 2 cells. Diagnosis: Cauda equina tumor.

Operations

11-9-36 - Laminectomy of 2d and 3d lumbar vertebrae was negative except for some thickening of the ligamentum flava.

1-22-37 - Laminectomy of 4th and 5th lumbar vertebrae was performed, and a smooth soft 4 mm. projection was found between the 4th and 5th lumbar vertebrae. This was removed and the excised tissue measured 1 x 2 cm., leaving a punched out opening into the intervertebral disc.

Microscopic examination

Cartilage cells with fibrillar stroma, suggesting elastic cartilage. Some areas of degeneration within it.

2-24-36 - Able to void. No pain. Is having trouble with hemorrhoids.

V. GOSSIP

Former interne John G. Lohmann was located at the Fergus Falls State Hospital, is now practicing in Jasper, Minnesota. This is about 16 miles from Pipestone where former intern Owen McElmeel is in practice. John is married, and very much in earnest to be about his father's business.....The Essex County Fair (nurses) will be held Friday, March 5th, from 8 to 12 P.M., at 500 Essex Street (where you are). The admission will be ten cents, which will entitle you to a chance at a real door prize. This is an opportunity to combine business with pleasure according to Chief Medical Nurse Nan Fleming who extends a personal invitation to each staff member to attend. ....The Minnesota State Funeral Directors and Embalmers' Association is in convention in St. Paul this week. The meeting, somewhat smaller than usual, does not have a commercial exhibit because of the convention of the National Association in Minneapolis this fall. This organization provides its members each year with a postmortem-embalming demonstration to further the cause of proper postmortem examinations. It also has a time for complaints and suggestions for improvement. Long (30 years) an ally

of the medical profession in this field, conditions in Minnesota are better than in most states. The cooperative plan stripped to essentials includes incisions which do not show after dressing the body, vessels left long enough to be used for injection, and a reasonable time for delivering the body. Much of the criticism (from both sides) as far as it affects this institution, is due to misunderstanding.....The social service supervisors are at the Center for Continuation Study this week, to be followed by the Waterworks Engineers. A few winters ago, the Waterworks Engineers and the Twin City Urologists met in adjoining rooms at the Lowry Hotel--believe it or not.....Classes in Roentgenologic Diagnosis (April 12 to 17), Irradiation Therapy (April 19 to 21), and Physical Therapy (April 22 to 24) are the next medical offerings at the Center for Continuation Study. The courses differ from those offered in the winter in that they will be held only if a sufficient number are registered prior to April 1st. The success of the plan will depend on getting together interested physicians who want a certain subject at the time we can offer it. We should not give courses which we think the physicians need, but rather those which they want. Drs. Rigler, Stenstrom and Knapp will be in charge.....Dr. Harold O. Peterson, department of roentgenology, who prepared today's meeting, is one of Minnesota's own, who went East for his training and then came back home. His special interests are those procedures which will aid in a diagnosis of disorders in the central nervous system. We are very glad that he has joined our group, for he has a great deal to offer as today's contribution testifies..... Chief Surgeon Owen H. Wangenstein has been elected vice-president of the Western Surgical Society.....Drs. Hemingway and Stenstrom are co-authors of one of the sections in the official handbook of the American Medical Association on Physical Therapy..... Hi-Ho, the official motif of the Essex County Fair, displayed on their cards about the building, has everyone singing the tune.

Adios.