Prophylaxis of the laminectomy membrane

An experimental study in dogs

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Sixty laminectomies were performed in dogs to investigate the prevention of the laminectomy membrane and its side effects. These operations were distributed in six groups of 10, one was a control group, and in the others the bone defect was protected with different materials (Oxicel, Silastic, Dacron, methyl methacrylate, and Kiel bone graft). After a survival of 2 months, suboccipital myelography was performed, immediately after which the animals were sacrificed and the operated spinal slice obtained. The different radiographic densities of the tissues of each slice were calculated and the diverse histological nature identified by hematoxylin and eosin, periodic acid Schiff, Masson's trichrome, and Gomori's reticulin stains. Only the acrylic plastic and the Kiel bone graft prevented expansion of the scar tissue inside the spinal canal and adhesions between the dura and the cicatricial overlying muscles. Therefore, the authors suggest that a solid barrier is necessary to effectively prevent the so-called "laminectomy membrane."

Key Words • laminectomy membrane • laminectomy • cicatrix • dura mater

The "laminectomy membrane" is a dense fibrous cicatricial tissue that replaces the bone that has been removed at laminectomy and binds the dura to the overlying muscles. The name was first given to it by LaRocca and Macnab when they studied this scar formation in dogs. Recently the laminectomy membrane, or some similar structure, has been reported as the cause of postoperative symptoms in humans, and routine measures for its prevention have been advocated.

The purpose of this report is to comment on the results of our experiments attempting to prevent this scar formation in dogs. Different materials were used to isolate the dura from the neighboring structures.

Material and Methods

We operated on 23 mongrel dogs; three of these died, leaving 20 for inclusion in this study. With the dogs under general anesthesia, a vertical midline incision was made on the dorsolumbar region, and the spinous processes and laminae were subperiosteally exposed. Three laminectomies were performed by rongeur in each dog, with an intact vertebral space between each operative site. In this way, 60 laminectomies...
**TABLE 1**

*Summary of histological findings in six groups of dogs*

<table>
<thead>
<tr>
<th>Histological Findings</th>
<th>Control</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>size of fibrous scar</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>density of mature collagen fibers</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>adhesions to posterior aspect of dura</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>radiographic density of fibrosis</td>
<td>+++</td>
<td>+++</td>
<td>+++†</td>
<td>+++†</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>scar invasion of foreign material</td>
<td>+++</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>newly formed capsule</td>
<td>—</td>
<td>+++</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>osteoid formation at bony ends of laminectomy</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

*+++ denotes the maximum of each item, and — denotes its absence.
†More marked in the capsule.
‡Only in its posterior aspect.

**Fig. 1.** Different radiographic tissue densities of the operated spinal slices in each group. a: Control group. b: Oxicel group. c: Silastic group. d: Dacron group. e: Acrylic group. f: Kiel bone graft group. For description see text.
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were performed, distributed in six groups of 10.

In the control group of 10 cases, the dura was completely exposed and the wound was closed in three layers: muscle, subcutaneous fat, and skin. The same procedure of suturing was used in all of the experimental groups. In Group 2, the bone defect was packed with Oxicel. In Group 3, the bone defect was covered with a Silastic sheet in contact with the dura. In Group 4, a Dacron sheet was used to isolate the dura from the overlying sutured muscles. In Group 5, molded methyl methacrylate was used to fill up the margins of the laminectomy. Finally, in Group 6, a piece of Kiel bone graft, shaped to cover the bone defect, was used. This bone sheet graft had a cortical and a spongy layer and the latter was placed in contact with the dura. Care was taken when performing laminectomies of different groups in the same animal, to avoid any external influence on the scar reaction to a specific material.

Two months after the operation, a myelographic study was performed using suboccipitally injected water-soluble medium. Immediately after this examination each dog was sacrificed and blocks made of the operated vertebra and overlying tissues. Each block was then cut in slices 0.5 cm thick. Radiography was then performed on each slice with a 0.3 thin x-ray focus to obtain images of the different tissue densities. After laboratory processing, the material was studied with hematoxylin and eosin, Masson's trichrome, and Gomori's reticulin stains.

Results

Table 1 summarizes the changes observed in each experimental group in comparison with the control group.

Control Group. The control group showed in all cases a "laminectomy membrane." This consisted of a thick fibrous scar growing from the dorsal muscle suture and expanding forward, filling the laminectomy defect and invading the lateral extradural spaces of the spinal canal. The scar tissues were closely adherent to the dorsal face of the dura. The radiographic density of this membrane was very similar to that of the overlying muscles (Fig. 1 a). The myelograms frequently showed a small indentation in the posterior subarachnoid column, probably caused by impingement of the scar tissue over the dura (Fig. 2). The histological analysis demonstrated mature collagen as the principal component of the scar tissue with rare diffuse fibroblasts. A few reticulin fibers were associated with the vessels. The connective tissue was firmly attached to the dura in all cases. This adhesion was mainly collagenous (Fig. 3 upper left).

Group 2. In the group packed with Oxicel, the findings were similar or more prominent (Fig. 1 b). The myelogram showed in many cases that the posterior dura was displaced anteriorly (Fig. 2). On histological analysis the structure of the membrane appeared almost identical to that of the control group (Fig. 3 upper right), although many granulomas with mononuclear and foreign body cells and abundant fibroblasts were seen near the remains of the Oxicel.

Group 3. In dogs with a Silastic covering, a new feature was apparent. A very thick, dense tissue reaction was observed forming a capsule around the Silastic sheet, so that when the foreign material was removed a cavity remained in its place. The dura was fixed to the anterior aspect of this capsule (Fig. 1 c). The myelogram was normal in all cases but one in which a small posterior compression was noted. Histological examination demonstrated that the capsule was mainly composed of mature collagen fibers arranged in concentrical layers around the Silastic.
Fig. 3. Photomicrographs showing reaction after laminectomy in four groups. Upper Left: Control group. Upper Right: Oxicel group. Lower Left: Dacron group. Lower Right: Acrylic group. For description see text. Masson's trichrome stain, × 4.
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FIG. 4. Photomicrographs showing reaction after laminectomy in two groups. Left: Silastic group. Right: Kiel bone graft group. For description see text. Masson's trichrome stain, × 4.

lamina. Inside these layers some cartilaginous and embryonic bone of metaplastic nature was found in some cases. The Silastic did not act as a protective barrier because the fibrous reaction enclosed it, invading the spinal canal and fixing the dura (Fig. 4 left).

**Group 4.** In the Dacron series, the findings were similar to those in the other groups. The cavity occupied by the Dacron also had a thick, dense fibrous wall that was adherent to the dura (Fig. 1 d). In only one case was the dura almost completely unattached. Myelography was always normal. Histological examination showed the same structure as the Silastic group (Fig. 3 lower left).

**Group 5.** In the group with molded methyl methacrylate, notable changes were observed. Although the acrylic provoked reactive fibrous thickening of the neighboring tissue, this was limited to its posterior aspect, leaving the dura free of adhesions (Fig. 1 e). Myelograms were always normal (Fig. 2). The stained preparations showed mature collagen fibers forming the scar behind the cavity left by the acrylic, but the spinal canal and dorsal aspect of the dura were free of connective tissue (Fig. 3 lower right). In some specimens the space between the dura and the plastic was occupied by a thin layer of fat which contained some normal reticulin fibers.

**Group 6.** In the group with Kiel bone graft this cicatricial tissue also appeared around the bone graft, mainly in its posterior aspect. In some cases slight low-density adhesions to the dura were apparent (Fig. 1 f). Myelograms were normal in all cases. The trabecular structure of the graft remained intact without reabsorption and with evident fibrous proliferation among the trabeculae. Some normal growth from the laminectomy bone edges advances spread into the graft trabecular framework. The space between the graft and the dura was occupied by scanty collagen and reticulin fibers in some cases and by fat in others (Fig. 4 right).

**Discussion**

The "laminectomy membrane" is found in all experimental studies of this nature and is probably the cause of some postoperative complications. Therefore every attempt should be made to find a procedure to minimize it.

According to LaRocca and Macnab, the "laminectomy membrane" results from invasion of the postoperative hematoma by fibrous tissue. However, the muscular scar posterior to the bone defect and the fibrous layer of the periosteum can contribute directly to its origin. Therefore, "laminectomy membrane" will always be caused, even with the most gentle and precise surgical technique.

LaRocca and Macnab observed that, by interposing Gelfoam or a Silastic sheet between the muscles and the dura, the invasion of the spinal canal is avoided. More
recently, Kiviluoto noted that Gelfoam is not an efficient protection, and he achieved better results by interposing autografts of fat. Keller, et al. have since confirmed the latter results. We have often used fat grafts for covering the dura and for filling the empty intervertebral space after a disc removal, but in our experience this procedure did not avoid the firm adherence of the fibrous scar to the dura in patients operated on again later. Thus we attempted to find other methods of prevention.

Among the materials we investigated, our best results were obtained with Kiel bone graft and with methyl methacrylate. In dogs in which these methods were used, the fibrous invasion of the spinal canal was almost totally avoided and the dura remained free of adhesions. This fact seems to suggest that the best way to avoid cicatricial invasion is to interpose a solid barrier without interstices, carefully contoured to fit the bone defect between the dorsal muscles and the spinal canal.

In time the Kiel bone grafts are reabsorbed and finally replaced by fibrous tissue capable of ossification. This can be a long process, and more long-term experience is needed to determine the final protective results with this method.

The results obtained with acrylic are comparable to those obtained in human cranioplasty. In patients who require reoperation, separation of the methyl methacrylate plate from the cerebral dura has always been observed, even after long intervals between operations. In our experimental animals, use of this material has been the best method of prevention of the “laminectomy membrane,” at least over short periods. Our present purpose is to investigate if the initial good results with Kiel bone and methyl methacrylate are maintained or if they deteriorate in long-standing chronic cases.

References

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