Interfering Endplate Nutritional Pathway Causes Intervertebral Disc Degeneration In Adolescent Porcine Model

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Methods: Eight Danish landrace immature pigs were used. Under general anesthesia, a left-sided retroperitoneal approach was used to expose the lumbar spine. Lumbosacral junction was selected as disc7, then the others cranial to this level were marked in descending order to disc0. From disc3 to 6, one was stabbed by No.23 scalpel as positive control. One was blocked by bone cement in both sides. (Figure 1) Disc0 was as normal control. MRI was performed on a 1.5-T scanner before surgery and at termination. Sagittal T1, T2, T2-weighted 3D and sagittal T2 mapping scan were taken. Post-contrast T1-weighted images were obtained after injection of 0.3 mmol/kg gadolinium at 0.5, 5, 10, 20, and following every 10 minutes to 110 minutes.

Evaluation

Blocking area (%BLOCK-area) was defined as the percentage of maximum cement area parallel to the endplate. Degree of IDD was assessed by NP area, NP signal intensity and collapse of AF.6 Changes of disc height index (DHI) was expressed as %DHI = postoperative DHI / preoperative DHI as previous literatures; 7-9 change in NP area was calculated as %NP-area = postoperative NP area / preoperative NP area. In T2-mapping, ROI for the NP were defined manually and then fit mono-exponentially to a T2 decay equation. In postcontrast enhancement MRI, ROI for the NP was defined manually on the T2-weight images and copied to the series of post-contrast images. The intensity values within the ROI were measured and contrast enhancement was calculated as Enhancement Percentage (%) =(SIpost - SIpre) / SIpre, where SI is signal intensity. The data are expressed as the mean ± standard deviation.

Results: Seven pigs continued to the end. Seven discs in each group. The cement blocking area was 38.92 ± 10.05 % (from 27.09% to 50.56%).

An overview of the disc changes of three groups is showed in figure 2. IDD degree was evaluated in cement blocked discs(6 severe, 1 mild), in scalpel stabbed discs(6 mild, 1 normal), in normal controls(7 normal). The %DHI, %NP-area, T2 values are showed in Figure 3.

Abnormal diffusion pattern happened in the bone cement blocked discs. A summary of the post-contrast MRI is showed in figure 4. The time-intensity curve of NP is showed in Figure 5.

Discussion: As bone cement is wildly used in vertebroplasty just locating near the endplate, concerns about the interference of endplate nutritional pathway are reasonable. In our experiment, we did find obvious adjacent IDD in the young porcine model. Inconsistent with our results, IDD was not found in previous similar studies. By unilateral blocking the endplate in adult dog models, Hutton, et al.3 did not find any visible disc degeneration but some abnormal histology changes. By unilateral blocking and even injuring the endplate in mature goat models, Verlaan, et al.4 again did not find disc degeneration in histology. These might because the other side endplate pathway still provided adequate nutrition. Then, by injection bone cement covering 80% length of both sides endplate in sagittal plane in 7.2-year-old ewe models, Krebs, et al.2 also did not find significant disc degeneration. It might be the cancellous bone mixed in bone cement continuously provide certain marrow-endplate interface contacting. Because new bone formation around the bone cement indicated nutritional supply in the gap of bone and cement still existed in the same study.

In our experiment, adolescent porcine models(3-month-old)were utilized, and we scraped the cancellous bone near both end plate to make an empty shell, then fully filled the void with no gap by bone cement. Relatively sufficient blockage in the endplate pathway caused disc degeneration. In our study, discs from adolescent porcine model were still in developing stage and probably demanded more nutrition. The more demanding of nutrition makes these discs more vulnerable to shortage of nutrition supply, leading to more possible positive results.

Reductions in T2 values indicate the reduction of disc extracellular matrix and water content. The discs in the two intervention groups could be concluded to be pathologically degenerated. Cement blocked discs showed a decreased diffusion through the endplate pathway, or even further stage of endplate lesion and vascularisation viewed by post-contrast series MRI. These two
diffusion patterns in our study were described in detail by Rajasekaran et al. The two patterns both indicated the endplate nutritional pathway was interfered and diseased after bone cement intervention and consequently caused IDD.

**Significance:** Severely interfering endplate nutritional pathway in adolescent porcine model could result in disc degeneration. More concern about adjacent disc degeneration needs to be taken when using large amount of bone cement in vertebroplasty or balloon kyphoplasty treatments, especially in younger patients. While, as previous studies illustrated, a small amount of bone cement application or enough marrow endplate interface maintenance still remains a safe procedure.

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**References:**