

# A Mathematical Model of Clinical Diagnosis and Treatment on the Method of Fuzzy Duster Analysis

Bin Zhao<sup>1\*</sup>, Xia Jiang<sup>2</sup>, Kuiyun Huang<sup>1</sup>, Jinming Cao<sup>3</sup> and Jingfeng Tang<sup>4</sup>

<sup>1</sup>School of Science, Hubei University of Technology, Wuhan, Hubei, China

<sup>2</sup>Hospital, Hubei University of Technology, Wuhan, Hubei, China

<sup>3</sup>School of Information and Mathematics, Yangtze University, Jingzhou, Hubei, China

<sup>4</sup>National “111” Center for Cellular Regulation and Molecular Pharmaceutics, Hubei University of Technology, Wuhan, Hubei, China

## \*Corresponding author

Dr. Bin Zhao, School of Science, Hubei University of Technology, Wuhan, Hubei, China, Tel/Fax: +86 130 2851 7572; E-mail: zhaobin835@nwsuaf.edu.cn

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## Abstract

In the process of this paper, all the factors related to cervical scoliosis can be grouped into 6 kinds of factors (5 levels), and all the possibilities of the cervical scoliosis can be divided into five classes. A fuzzy logic study was performed on 318 patients who had undergone cervical scoliosis with our hospital from August 2013 to August 2018. And the clinical diagnosis and treatment on the method of fuzzy duster are analyzed with the mathematical model be established. Then, we study a new differentiated diagnosis method of cervical torticollis (scoliosis) by an Asian wild horse with fuzzy mathematics, and successfully treated after cervical nerve plexus block.

**Keywords:** Clinical Diagnosis; Treatment; Cervical Torticollis; Scoliosis; Fuzzy Cluster Analysis

## Introduction

In 1965, L.A.Zadeh proposed the important concept of fuzzy linguistic variables. Fuzzy logic makes the gray truth value into the complex structural system of formal reasoning, which is a new branch of machine intelligence. And fuzzy logic tried to make the computer use our gray common sense to reason. The fuzzy judgment Sentence is the same as the fuzzy reasoning sentence. It cannot give absolute truth and false, and can only give the degree of truth. Therefore, when applying fuzzy set theory to fuzzy reasoning of fuzzy propositions, fuzzy relation is used to represent fuzzy conditional sentences, which transforms the judgment process of reasoning into the process of synthesis and calculation of membership degree [1].

The process of traditional Chinese medicine (TCM) diagnosis and treatment can also be attributed to judgment, reasoning and inference. Therefore, the application of fuzzy reasoning for the diagnosis of cervical spondylosis is one of the methods used to describe TCM diagnosis and treatment in mathematical language.

In the Asian wild horse, acquired cervical torticollis (scoliosis), in which the cervical vertebrae are twisted or crooked, appears to be rare with few reported cases [2-3]. A variety of reasons are reported for acquired cervical scoliosis. Musculo-skeletal causes have included fracture/subluxation of cervical vertebrae, unilateral cicatricial muscle contracture, unilateral muscle rupture, unilateral

paralysis subsequent to cervical spinal nerve damage and nutritional dystrophic myo-degeneration [2]. This clinical report describes a technique for correction of an acquired cervical torticollis in a horse.

## A mathematical model on the method of fuzzy duster analysis

The analytical model is established to provide algorithmic support for the diagnosis and treatment of orthopedic diseases. Any mapping from the universe  $U = \{a_1, a_2, \dots, a_n\}$  to the closed interval  $[0, 1]$   $\underline{A}: U \rightarrow [0, 1]$ , for any  $u \in U$ ,  $u \xrightarrow{\underline{A}} \underline{A}(u)$ ,  $\underline{A}(u) \in [0, 1]$ , then  $\underline{A}$  is called a fuzzy subset of  $U$ ,  $\underline{A}(u)$  is called the membership function of  $U$ , which is also recorded  $\mu_{\underline{A}}(u)$ .

where

$$\underline{A} = \frac{\mu_{\underline{A}}(a_1)}{a_1} + \frac{\mu_{\underline{A}}(a_2)}{a_2} + \dots + \frac{\mu_{\underline{A}}(a_i)}{a_i} + \dots + \frac{\mu_{\underline{A}}(a_n)}{a_n},$$

$$a_i \in U (i = 1, 2, \dots, n), \quad 0 \leq \mu_{\underline{A}}(a_i) \leq 1.$$

Based on a large number of medical records, the five-element linguistic variable rules defined by L.A.Zadeh are used [4]. We determine the “extreme”, “equal”, “comparative”, “less”, “slight” five-level modifiers, and define the membership function according to expert experience. Let  $U$  be the domain that reflects the symptom set of cervical spondylosis ( $U = \{A B C D E F\}$ ). Among them,  $A$  is a symptom of root distribution;  $B$  is a symptom of neck pain;  $C$  is a symptom of spinal cord compression;  $D$  is a symptom of vertigo;  $E$  is a symptom of sympathetic nerve; and  $F$  is a degree of

bone hyperplasia of the neck. According to the judgment criteria of Table 1 and the sample survey results of 318 patients, the 6-input is described as  $R_1, R_2, \dots, R_5$ , which is shown below:

- $R_1$ : if  $x_1$  is  $A_1$  and  $x_2$  is  $B_1$ , and ...and  $x_6$  is  $F_1$ , then  $y$  is  $Z_1$ ;
- $R_i$ : if  $x_1$  is  $A_i$  and  $x_2$  is  $B_i$ , and ...and  $x_6$  is  $F_i$ , then  $y$  is  $Z_i$ ;
- $R_5$ : if  $x_1$  is  $A_6$  and  $x_2$  is  $B_6$ , and ...and  $x_6$  is  $F_6$ , then  $y$  is  $Z_5$ .

Among them,  $x_i$  is patient syndrome characterization;  $Z_i$  is type of cervical spondylitis, which is local, ridiculous, spinal, vertebral, and sympathetic type, respectively. So the fuzzy rule

$$R = \bigcup_{i=1}^5 R_i .$$

**Table 1: Judging the basis of cervical spondylosis type**

Type	Sympton	Sign	Film degree exam CT
Local type	Neck and shoulder pain	Neck tenderness, limited neck movement, no pathological reflex.	Disc herniation, degeneration, changes in physiological curvature.
Radiculous type	Neck and shoulder pain, murmur in the neck, root radiation pain, pain and the affected segment, the sensory disturbance associated with root pain and numbness, decreased sensation.	The muscles of the affected side are tense, the spine of the spine and the medial edge of the scapula are tender, the brachial plexus nerve pull test is positive, the shoulder and shoulder compression test is positive, the tendon reflex can be active early, and the late reduction or disappearance.	X-ray showed that the cervical vertebrae had a straight or occluded curvature, the intervertebral space narrowed, and the vertebral body hyperplasia. The corresponding segment sometimes showed calcification of the ligament, and CT or MRI showed nerve root compression.
Spinal type	Early manifestations of heavy and weak limbs, unstable walking, lack of activity, sometimes feel burning and numbness in the lower limbs. At the same time, often accompanied by difficulty in defecation, about 30% of patients with dizziness; late appearance of monoterpe, hemiplegia, paraplegia, quadriplegia.	The muscle tension of the limbs is increased below the lesion plane, the muscle strength is weakened, the tendon reflex is hyperthyroidism, and the shallow feeling is reduced. Pathological reflexes such as Hoffman sign and Babinski sign.	X-rays films often show vertebral body bone hyperplasia, spinal canal stenosis may occur, CT, MRI can be clearly diagnosed.
Vertebral type	Dizziness is related to body position. It often occurs when getting up, lying down, turning over, turning around, and lasting for a few seconds to ten seconds. The elderly can reach several days to one or two days. Sometimes it can cause vomiting, tripping, falling objects and other symptoms.	Head tilting neck test positive.	X-ray films showed hyperplasia of the hook joint and narrowed intervertebral space.
sympathetic type	Dizziness (unrelated to body position, often light in the morning, heavy in the afternoon), eyelids do not move, eyeballs swell, blurred vision, tinnitus, abnormal pharynx, neck discomfort, fatigue, insomnia, dreams, sweating, emotional excitement, Painful chest tightness.	The head back pressure neck test is often positive, the neck activity is not limited, and the neck test is negative.	X-ray examination can have vertebral body anterior and posterior marginal bone hyperplasia and cervical spondylolisthesis (often happen in neck 5).

Next, the fuzzy implication minimum computation (Mamdani) method is used to perform fuzzy analysis based on fuzzy rule base for pathological analysis. Mamdani's minimum arithmetic rules:

$$\mu'_i(z) = \alpha_i \wedge \mu_i(z)$$

$$\mu'_i(z) = \mu'_1(z) \vee \mu'_2(z) = [\alpha_1 \wedge \mu_1(z)] \vee [\alpha_2 \wedge \mu_2(z)]$$

Let fuzzy set  $I$  be a fuzzy subset of a patient's syndrome (the elements of  $I$  are determined by patient self-report and doctor's diagnosis), and the output fuzzy set is  $Z'$ . The patient's cervical spondylosis type is judged according to the principle of maximum membership. Of the 318 clinical cases, 100 cases were representative (divide 5 age groups, 20 in each group). The corresponding program was established in the professional mathematical analysis software Matlab, and the diagnosis of cervical spondylosis type was performed through the human-machine dialogue window.

### Case analysis

1) Male, 56 years old, determine the fuzzy subset of its syndrome,

$$I = [0.7 \ 0.5 \ 0.1 \ 0.1 \ 0.1 \ 0.8],$$

$$Z' = I \circ R = [0.9 \ 0.5 \ 0.1 \ 0.1 \ 0.1 \ 0.8] \circ \begin{bmatrix} 0.0 & 1.0 & 0.6 & 0.0 & 0.2 \\ 0.9 & 0.6 & 0.4 & 0.5 & 0.3 \\ 0.1 & 0.2 & 1.0 & 0.3 & 0.2 \\ 0.1 & 0.2 & 0.1 & 1.0 & 0.8 \\ 0.0 & 0.0 & 0.0 & 0.6 & 1.0 \\ 0.1 & 0.8 & 0.8 & 0.6 & 0.3 \end{bmatrix} = [0.5 \ 0.9 \ 0.6 \ 0.6 \ 0.3].$$

Which is  $Z' = \frac{0.5}{Z_1} + \frac{0.9}{Z_2} + \frac{0.6}{Z_3} + \frac{0.6}{Z_4} + \frac{0.3}{Z_5}$ ,

judging the patient as a nerve root patient

According to the principle of maximum membership

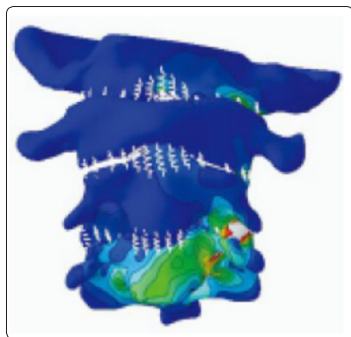
- 2) Male, 47 years old, dizziness, nausea, retching, the same reason for sympathetic type.
- 3) Female, 41 years old, dizziness, and the same reason is the vertebral artery type.
- 4) Female, 27 years old, neck acid pain and pain, the same reason for the local type.

Through the confirmatory analysis of the above 5 groups of typical cases, which can be seen that this method has certain clinical guiding significance for the type diagnosis of cervical spondylosis. The fuzzy reasoning method for cervical spondylosis established is based on the syndrome differentiation level of many TCM experts, which avoids the subjective factors of a single doctor and becomes more objective.

### Clinical findings and methods

A 6-year-old male Asian wild horse was presented to the surgery clinic of the faculty of Hospital, Hubei University of Technology, with a history of 3 days duration of a deviated neck. The owner reported that the horse developed severe neck deviation following tying of the horse head with a short rope combined with unsuccessful attempts to release the hanged head with recumbence.

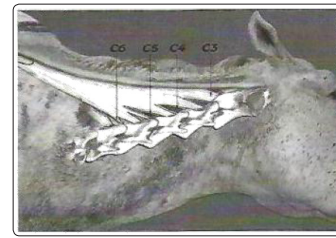
Physical examination revealed the presences of neck deep abrasion from the rope. There was severe torticollis of the neck to the left with inability to raise the head up. The concavity of the deviated neck occupied the right mid-neck side (Figure 1). Neurological examination was normal. Radiography of the cervical vertebrae did not show any bony or articular lesions.



**Figure 1:** A 6-year-old Asian wild horse with acquired cervical scoliosis

The horse was anesthetized and positioned in lateral recumbency on the left side. Aseptic preparation of the right concave side of the affected neck was performed. The wing of the atlas as well as the transverse process of the subsequent cervical vertebrae was palpated at the concave right side of the neck as far as caudally to the level of C6.

With deep digital pressure, the intervertebral indentations between the cervical vertebrae were palpated and marked with a marker pen indicating the landmarks of the branches of the dorsal cervical nerve plexus from C3 to C6. A 12 cm long and 21 gauge spinal needle was inserted through the skin at the first landmark (C3) in the intervertebral depression until it stuck the articular process of cervical vertebra. Little withdrawal of the needle allowed contact with the target nerve. Then 10 ml of Mepivacaine HCl 2% and 40 mg Triamcinolone Acetonide (Kinacort, Squibb, Egypt) suspension were injected and distributed in the vicinity of the nerve. The other landmarks of the subsequent dorsal cervical branches (C4, C5 & C6) were similarly treated (Figures 2 & 3). Successful infiltration was indicated by full analgesia including the skin within 10 minutes associated with rise of skin temperature. By gentle massaging of the involved muscles of the neck, the twisted vertebrae assumed their normal position. A side sticks between the head and neck collar was fixed while the head was tied to a high wall ring, eating from a high hay rack for 48 hours.



**Figure 2:** The exits of dorsal cervical nerve



**Figure 3:** The landmarks of injection sites plexus (C3-C6) in relation to cervical vertebra

Fast improvement was achieved after 48 hours the neck of the horse assumed normal attitude. The animal was discharged with instructions to continue box confinement and fixing of the head in high position, eating from a high rack, daily neck massaging with methyl sulfonyle methane (MSM ointment and oral phenylbutazone 4mg/kg) bid for one extra week.

### Conclusion

From the case history, the presented report of acquired cervical torticollis after accidental trauma of the neck was related to severe spasmodic contraction of the lateral cervical muscles and the attached ligamentum nuchae without involvement of the vertebrae. Musculoskeletal and neurogenic caused were reported due to cervical nerve damage or dorsal grey column myelitis [2,3]. Recently, parasitic (verminous) sensory myelitis by strongylus tenuis was also implicated [3]. Early therapeutic measures should be considered in acquired cervical torticollis of non-neurogenic or skeletal origin since secondary focal articular changes in the articular processes were developed, varying from enlargement on the convex side to fibrosis with hemorrhage and granulation tissue formation on the concave or fractures of the articular processes of the vertebrae associated with abnormal loading and immobilization of the vertebral column [5]. The dorsal cervical plexus nerve block proved its efficiency and simplicity for treatment of acquired spasmodic torticollis of non-neurogenic or skeletal lesions in the horse. The dorsal cervical nerve plexus formed by connections of the dorsal branches of C3-C6 via communicating branches is the major nerve supply to the lateral aspect of the neck. The lateral branches of the dorsal branches of the cervical nerves from the main motor supply to the dorsolateral muscles of the neck while the medial branches supply the deep lateral muscles and the skin [6, 7]. Injecting the local analgesic Mepivacaine HCl 2% releases the spasticity of the involved muscles of the Neck and provides the requested analgesia for free mobility which helps the remodeling of the affected muscles the addition of potent steroidal anti-inflammatory Triamcinolone acetonide is very important to alleviate myositis and desmitis in the affected region [8,9].

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