

Research Article

Correlation analysis between characteristics under gastroscop and image information of tongue in patients with chronic gastritis

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Abstract

OBJECTIVE: To explore the correlation between diagnostic information of tongue and gastroscopy results of patients with chronic gastritis.

METHODS: Frequent pattern growth (FP-Growth), SPSS Modeler was used to analyze the correlation rules between the image information of tongue parameters and the characteristics of the stomach and duodenum seen under gastroscopy.

RESULTS: Ranking in order of confidence: cyanotic

tongue, slippery fur, yellow fur and spotted tongue were sequentially associated with both gastric antrum mucosal hyperemia or edema and gastric antrum mucosal erythema/macula. L, one value of tongue coating color, which counted among (30, 60), tooth-marked tongue and b, one value of tongue coating color, which counted in the range of (5, 20) were sequentially associated with gastric antrum mucosal erythema /macula. A, one value of tongue body color, which counted in the range of (0, 20), was related to both gastric antrum mucosal hyperemia or edema and gastric antrum mucosal erythema /macula. a, one value of tongue coating color, which counted in the range of (15, 35), was associated with gastric antrum mucosal erythema / macula. There are a total of 9 strong correlation rules.

CONCLUSIONS: Cyanotic tongue, slippery fur, yellow fur, the CIE Lab value of tongue coating, a, the value of tongue body color, spotted tongue, and tooth-marked tongue are all related to the gastric antrum mucosal hyperemia or edema and gastric antrum mucosal erythema / macula. The conditions of gastric mucosa could be predicted by the examination of the above related image information of tongue.

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Keywords: gastritis; tongue; stomach; duodenum; correlation of data; frequent pattern growth algorithm

1. INTRODUCTION

The incidence of chronic gastritis is high in China, however, this disease has no specific clinical manifestations. Studies have confirmed that the gastrointestinal symptoms and their severity have no significant relationship with the performance under gastroscopy and pathological classification. So the early detection of chronic gastritis comes to be a key problem.^{1,2} Gastroscopy and biopsy histopathology are important diagnostic methods for chronic gastritis. However, due to its invasiveness and insufficient resource allocation in medical institutions, gastroscopy cannot be fully popularized. The diagnosis rate of chronic gastritis has declined to some extent. The diagnosis of Traditional

Chinese Medicine (TCM) has been gradually modernized, and this non-invasive examination method can be used in the diagnosis of chronic gastritis. However, before it is put into use, a large number of researches are needed to confirm the feasibility and provide a theoretical basis. In order to further confirm the correlation between the image information of tongue and performance under gastroscopy of the patients with chronic gastritis, we collected and sorted out the results of TCM four-examination and gastroscopy examination of patients treated in the Gastroenterology Department of Beijing TCM Hospital from July 15, 2019 to December 3, 2019. The correlation between the image information of tongue and the characteristics of the stomach and duodenum under the gastroscope of the patients with chronic gastritis was analyzed, so as to lay the foundation for the application of non-invasive examination of TCM in the early detection of chronic gastritis.

2. MATERIALS AND METHODS

2.1. Diagnostic criteria

The diagnostic criteria for chronic gastritis and its specific types were based on the "China's Consensus Opinions on Chronic Gastritis (2017, Shanghai)".³ Doctors made diagnosis mainly according to the results of the endoscopy examination and the histopathological examination. There were Alcian Blue (AB) staining, Periodic Acid Schiff (PAS) staining, Hematoxylin-eosin (HE) staining used in staining of gastric mucosa. Meanwhile, *Helicobacter pylori* (Hp) was detected by using immunohistochemical method. Examination results of *Helicobacter pylori* infection, which detected in rapid urease test, and four indexes of serum gastric function, including pepsinogen I (PG I), pepsinogen II (PG II) and gastrin-releasing 17 (G-17), PG I/PG II (PGR), were used as auxiliary examinations which help making accurate diagnosis.

2.2. Exclusion criteria

Exclusion criteria were as follows: (a) Patients with malignant tumors or upper gastrointestinal bleeding; (b) patients with serious primary diseases such as heart, brain, kidney and hematopoietic system or mental illness; (c) pregnancy or preparing to become pregnant, lactating women; (d) Patients with recent colds and various acute diseases; and (e) Patients whose tongue diagnosis information and endoscopy examination results are incomplete.

2.3. Clinical materials

A total of 174 patients were selected from those treated in the Department of Gastroenterology of Beijing Traditional Chinese Medicine Hospital from July 15, 2019 to December 3, 2019. The MT-BX-01 portable Chinese health information acquisition instrument (Tianjin Medvally Technology Co., Ltd., Tianjin, China) was used to collect the TCM diagnosis information of

those patients with chronic gastritis. The following indexes were obtained from the examination results of the TCM diagnosis: tongue condition, tongue mobility, color of tongue texture and its corresponding CIE Lab value, color of tongue fur and its corresponding CIE Lab value, fur quality, tongue shape, and status of sublingual collaterals. OLYMPUS EVIS LUCERAELITE CV-290 CV-290SL electronic gastrointestinal endoscopy system (OLYMPUS Medical Systems Corporation, Tokyo, Japan) was used to perform gastroscopy on patients. Record the following indexes in the results of gastroscopy: diagnosis opinion and description of esophagus, cardia, fundus, stomach body, gastric horn, antrum, pylorus, duodenal bulb, desc-ending part of duodenum. This research has passed the ethical review. The research plan meets the requirements of scientific and ethical principles. In the process of handling informed consent, the relevant information materials were provided to the subjects (or their families, guardians, legal agents). Confidentiality measures were taken for the subjects' data.

2.4. Data processing

To unify data representation format, firstly, the corresponding Lab value of tongue quality and tongue coating color adopted standard chromaticity of the Lab color space specified by the International Commission on Illumination.⁴ All colors of tongue texture and tongue fur were expressed in the form of CIE Lab values. The rest image information of the tongue included lustrous tongue, normal tongue state, light red tongue, red tongue, crimson tongue, cyanotic tongue, white fur, yellow fur, thin fur, rot fur, greasy fur, thick fur, moist fur, slippery fur, mirror tongue, fat tongue, thin tongue, soft tongue, normal sublingual collaterals, thin and short sublingual collaterals with light color, varicose and dilated sublingual collaterals with deep color and even accumulation of stasis, spotted tongue, tooth-marked tongue, fissured tongue, and ecchymosis. Secondly, standardize the description of the characteristics of each part of the stomach and duodenum seen under the gastroscope. The standardized characteristics description included smooth esophageal mucosa, orange-red island-like mucosa, longitudinal injury in lower esophageal mucosa, rough esophageal mucosa / esophageal nodules / esophageal protuberance / esophageal macula / esophageal erosion, esophageal ulcer, revealed light blue esophageal collaterals, good esophageal contraction and relaxation, normal cardia mucosa, cardia mucosal injury, cardia mucosal hyperemia, cardia mucosal roughness / protrusion / macula / erosion / hernia sac, good cardiac contraction and diastole, (slightly) loose cardia, clear dentate, irregular dentate / mucosal damage near the dentate, clear mucus lake, the mucus lake mixed with a small amount of yellow (green) turbid gastric fluid / foamy mucus lake, the smooth fundus mucosa, bleeding / hyperemia / thin collaterals in the fundus mucosa, the fundus mucosal edema, the fundus mucosal bulge / polyposis / macula / erosion / hernia sac, gastric fundus

varices, smooth gastric body mucosa, hyperemia / erythema in the gastric body mucosa, mucosa edema of gastric body, ulcer and mass / erosion in the gastric body, arc shape of gastric angle, smooth gastric angle mucosa, rough gastric angle mucosa, gastric angle mucosa covered with yellow secretions, edema / hyperemia / ulcer / erosion in the gastric angle mucosa, good gastric antrum peristalsis, gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, gastric antrum mucosa appearing in color of white alternating with red and revealed collaterals, gastric antrum mucosa covered with yellow secretions, normal gastric folds, flattened or even disappeared gastric folds, hypertrophy / edema of gastric folds, gastric antrum mucosal erosion, gastric antrum mucosal ulcer and tumors, intestinalized plaque of gastric mucosa, good pyloric opening and closing, bile regurgitation in the pylorus, lasting-open pylorus, normal morphology of the duodenal bulb, deformation of the duodenal bulb, hyperemia of the duodenal bulb mucosa, granular hyperplasia / erythema / ulcer / erosion / scarring of the duodenal bulb mucosa, normal morphology of duodenal papilla, minor duodenal papilla, normal duodenal mucosa, and the hyperemic / protruded duodenal mucosa.

2.5. Data input

Information of patients, examiners, and instrument, tongue diagnosis information of TCM, and gastroscopy results were input into Microsoft Excel. All the above information was input by one single person and checked twice.

2.6. Data cleaning

In order to meet the requirements of modeling, the descriptions of tongue diagnosis information including tongue spirit condition, tongue mobility, color of tongue texture and its CIE Lab value, color of tongue fur and its CIE Lab value, fur quality, tongue shape, and status of sublingual collaterals were listed in lines, and the results of tongue diagnosis were represented in the form of “0” (no) and “1” (yes). The results of gastroscopy examination were classified into rows according to different parts of stomach, and the details of them were displayed in the form of “0” (no) and “1” (yes). To sum up, there were 85 columns and 175 rows.

2.7. Data mining

IBM SPSS Modeler Subscription version 1.0 (International Business Machines Corporation, NY, USA) was used to construct a “data source-type-correlation rule-network” data flow. The correlation rule analysis was performed to analyze the relationship between the image information of tongue and the characteristics of the stomach and duodenum seen under the gastroscope of patients with chronic gastritis. The predefined role was used in the correlation rule field, and the algorithm was set to be frequent pattern growth (FP-Growth) in the rule construction. In the correlation rule model, the conditions

were set to be light red tongue, red tongue, crimson tongue, cyanotic tongue, color of tongue body: L1 (35, 70), a1 (0, 20), a1 (20, 40), b1 (-5, 10), B1 (10, 25), white fur, yellow fur, color of tongue fur: L2 (30, 60), L2 (60, 90), a2 (-5, 15), a2 (15, 35), b2 (-10, 5), b2 (5, 20), thin fur, rot fur, greasy fur, thick fur, moist fur, slippery fur, mirror tongue, fat tongue, thin tongue, soft tongue, normal sublingual collaterals, thin and short sublingual collaterals with light color, varicose and dilated sublingual collaterals with deep color and even accumulation of stasis, spotted tongue, tooth-marked tongue, fissured tongue, and ecchymosis. The prediction was set as the characteristic description of each part of the stomach and duodenum. Confidence degree was set as the rule standard, the maximum number of rules was set as 1,000, the minimum confidence degree was set as 80%, the minimum conditional support degree was set as 5%, the minimum rule support degree was set as 5%.

3. RESULTS

After the model was run, 11 of the most frequent items were obtained. Among them, the value of “L” represents the brightness of the pixel, ranging from 0 to 100 means color changes from pure black to pure white.⁵ “L2” in the range of (30, 60) indicates that the brightness is moderate and slightly closer to brightness than darkness. The value of “a”, ranging from 127 to -128 means that the color changes from red to green. So a1 among (0, 20) means that the color of tongue body is reddish, and a2 in the range of (15, 35) means that the color of tongue coating is reddish. The value of “b” ranging from 127 to -128 means that the color changes from yellow to blue. Then b2 in the range of (5, 20) means that the tongue coating color is closer to yellow. A total of 14 rules were obtained (Table 1). In summary, there are 9 strong association rules as follows: cyanotic tongue → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, slippery fur → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, yellow fur → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, spotted tongue → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, L2 (30,60) → gastric antrum mucosal erythema / macula, a1 (0, 20) → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, tooth-marked tongue → gastric antrum mucosal erythema / macula, b2 (5, 20) → gastric antrum mucosal erythema / macula, a2 (15, 35) → gastric antrum mucosal erythema / macula (Table 2).

4. DISCUSSION

According to the above results, the most frequent items include cyanotic tongue, slippery fur, yellow fur, a1 (0, 20), spotted tongue, L2 (30, 60), b2 (5, 20), a2 (15, 35), tooth-marked tongue, gastric antrum mucosal hyperemia or edema, and gastric antrum mucosal erythema / macula.

Table 1 Information about the most frequent items (%)

Item name	Record	Condition	Prediction
Gastric antrum mucosal erythema / macula	80.46	0.00	64.29
Tooth-marked tongue	79.31	7.14	0.00
Gastric antrum mucosal hyperemia or edema	77.01	0.00	35.71
a2 (15, 35)	66.67	7.14	0.00
b2 (5, 20)	60.34	7.14	0.00
L2 (30, 60)	48.28	7.14	0.00
spotted tongue	28.16	14.29	0.00
a1 (0, 20)	26.44	14.29	0.00
Yellow fur	11.49	14.29	0.00
Slippery fur	8.62	14.29	0.00
Cyanotic tongue	5.75	14.29	0.00

Notes: a1: the range of tongue body color from red to green; a2: the range of tongue coating color from red to green; b2: the range of tongue coating color from yellow to blue; L2: the brightness of the tongue coating color.

Table 2 Most relevant rules (based on: confidence)

Rank	Condition	Prediction	Sorting by confidence (%)	Other assessment statistics			
				Conditional support (%)	Rule support (%)	Lift	Deployability (%)
1	Cyanotic tongue	Gastric antrum mucosal hyperemia or edema	100.00	5.75	5.75	1.30	0.00
2	Cyanotic tongue	Gastric antrum mucosal erythema / macula	100.00	5.75	5.75	1.24	0.00
3	Slippery fur	Gastric antrum mucosal hyperemia or edema	93.33	8.62	8.05	1.21	0.57
4	Yellow fur	Gastric antrum mucosal erythema / macula	90.00	11.49	10.34	1.12	1.15
5	Spotted tongue	Gastric antrum mucosal erythema / macula	87.76	28.16	24.71	1.09	3.45
6	Slippery fur	Gastric antrum mucosal erythema / macula	86.67	8.62	7.47	1.08	1.15
7	L2 (30, 60)	Gastric antrum mucosal erythema / macula	85.71	48.28	41.38	1.07	6.90
8	Yellow fur	Gastric antrum mucosal hyperemia or edema	85.00	11.49	9.77	1.10	1.72
9	Tooth-marked tongue	Gastric antrum mucosal erythema / macula	83.33	79.31	66.09	1.04	13.22
10	b2 (5, 20)	Gastric antrum mucosal erythema / macula	82.86	60.34	50.00	1.03	10.34
11	a1 (0, 20)	Gastric antrum mucosal hyperemia or edema	82.61	26.44	21.84	1.07	4.60
12	a1 (0, 20)	Gastric antrum mucosal erythema / macula	82.61	26.44	21.84	1.03	4.60
13	Spotted tongue	Gastric antrum mucosal hyperemia or edema	81.63	28.16	22.99	1.06	5.17
14	a2 (15, 35)	Gastric antrum mucosal erythema / macula	81.03	66.67	54.02	1.01	12.64

Notes: a1: the range of tongue body color from red to green; a2: the range of tongue coating color from red to green; b2: the range of tongue coating color from yellow to blue; L2: the brightness of the tongue coating color.

The result suggests that chronic gastritis is related to stagnant blood, spleen deficiency, dampness and pathogenic heat, which is consistent with the existing result by cluster analysis of gastritis syndromes.⁶ Among them, the probability of cyanotic tongue → gastric antrum mucosal hyperemia or edema and gastric antrum mucosal erythema / macula is both 100%, while the support is 5.75% and the lift is 1.30 and 1.24 respectively. The cyanotic tongue is a sign of stagnant blood, and the strong correlation between the cyanotic tongue and the two indicates that the condition of gastric antrum mucosal hyperemia, edema, erythema, and macula can be predicted by observing the presence of the cyanotic

tongue. When there is stagnant blood in the body, the blood flow slows down or even stagnates. In the state of high blood viscosity and high coagulation, the mucosa will become hyperemic and edematous. Slow blood supply leads to tissue ischemia and hypoxia, then the color of the mucosa is not well-proportioned and appears as erythema or macula, which is similar to the mechanism of blood stasis of chronic atrophic gastritis proposed by scholars.^{7,8} The confidence of slippery fur → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula is 93.33% and 86.67%, respectively, while the conditional support is 8.62%, the rule support is 8.05% and 7.47%, and the lift

is 1.21 and 1.08, respectively. This strong correlation rule suggests that the condition of hyperemia, edema, erythema, and macula of gastric antrum mucosa can be predicted by observing the presence of slippery fur. In addition, there is a strong correlation between tooth-marked tongue and gastric antrum mucosal erythema / macula. Slippery fur is the manifestation of dampness, the main cause of dampness is insufficiency of spleen *Qi* or deficiency of *Yang Qi* of spleen and kidney. Insufficient power to move blood circulation and low function of *Qi* result in dampness retention. The low function of *Qi* can be manifested as poor blood flow in modern medicine field, which causes insufficient protein exchange through capillaries. As a result, the body can't maintain normal osmotic pressure. Then tissue edema happens. The gastric manifestations are mucosal hyperemia or edema and the asymmetrical color distribution of mucosa. Therefore, the condition of hyperemia, edema, erythema, and macula of gastric antrum mucosa can be predicted by observing the presence of slippery fur and tooth-marked tongue. yellow fur → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, spotted tongue → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, L2 (30,60) → gastric antrum mucosal erythema / macula, a1 (0, 20) → gastric antrum mucosal hyperemia or edema, gastric antrum mucosal erythema / macula, b2 (5, 20) → gastric antrum mucosal erythema / macula, a2 (15, 35) → gastric antrum mucosal erythema / macula, the above 6 strong correlation rules suggest that by monitoring the information of yellow fur, CIE Lab value of tongue fur, the value of a (which represents the red and green color of tongue body), and spotted tongue, we can predict the hyperemia or edema of the gastric mucosa, erythema and plaques of the gastric mucosa. The above 6 indications about the image information of tongue are all seen as heat syndromes in TCM syndrome differentiation. On the one hand, the blood is forced to run fast by pathogenic heat. On the other hand, the blood vessels are scorched. Then the blood overflows outside vessels, forming hematoma and mucosal erythema. Some scholars have suggested that the inflammatory activity of the gastric mucosa weakens the digestive function. At this stage, there are too many filamentous nipples and gas-producing microorganisms in the tongue. So the saliva secretion decreases, and cause inflammatory exudation of the tongue. All the factors contribute to the yellow fur.⁹

In summary, the research initially confirmed that the information of cyanotic tongue, slippery fur, yellow fur, CIE Lab values of tongue fur, the value of "a", spotted tongue, and tooth-marked tongue is related to gastric antrum mucosal hyperemia, edema, erythema and macula, which has a theoretical basis. Therefore, the status of gastric mucosa can be predicted by monitoring the above relevant image information of tongue. Referring to the recent relative studies, the image information of tongue is manually identified. Due to the subjectivity of each individual doctor, it seems

unavoidable to cause any error that may affect the accuracy of the analysis results.^{10,11} In terms of the research content, most of the studies stay at the classification stage of spleen and stomach diseases, and only a few of the studies^{12,13} have refined the gastric changes of the mucosal morphological level. In terms of the research methods, studies^{14,15} use instruments to complete the digital collection of tongue image information, but the analysis method is the hypothesis testing method such as χ^2 test. This type of analysis method requires hypotheses before testing, which limits the analysis scope. There is a drawback to illustrate the correlation between two dimensions. By calculating the incidence of the target field in a certain disease, the detailed information of each dimension could be easily neglected, which would affect the comprehensiveness and the objectivity of the results. In this study, MT-BX-01 the portable Chinese health information acquisition instrument was used to collect tongue diagnosis information in order to ensure the objectivity of the data. FP-Growth algorithm in the correlation rules was used to analyze the dependence and correlation between the image information of tongue and characteristics of the stomach and duodenum under gastroscopy. Correlation rule analysis is more appropriate for mining data relationships than other statistical analysis methods. And FP-Growth algorithm in association rules is more appropriate for data mining than Apriori algorithm in the field of Traditional Chinese Medicine, which has better performance than the latter.¹⁶ Therefore, to improve the credibility, the above method was used to analyze the correlation rules of tongue image information and characteristics of the stomach and duodenum under gastroscopy of patients with chronic gastritis.

According to the pathological changes, chronic gastritis is divided into chronic non-atrophic gastritis and chronic atrophic gastritis. Chronic atrophic gastritis is prone to develop into gastric cancer, whose pathological characteristics under gastroscopy are atrophy of gastric glands, thinning of gastric mucosa, and thickening muscular layer of mucosa, accompanied by intestinal metaplasia and atypical hyperplasia of gastric mucosa³. Real-time monitoring of precancerous lesions is extremely important to improve the quality of life, and it is necessary to pay more attention to the conditions of the gastric mucosa and glands. Objective diagnosis of TCM can be applied in the diagnosis of chronic gastritis. This non-invasive examination method can be adopted to detect the changes of the condition in the stomach by observing the image information of tongue. The noninvasive examination of TCM can be used as a preliminary screening method. Studies have confirmed that the detection of serum gastrin G17 and pepsinogen I and II helps to determine whether there is atrophic lesions in gastric mucosa or not.^{17,18} So as to predict the conditions of gastric mucosa, we used the above indexes as reference. Once the relevant abnormal value is found, further examinations of gastroscopy and histopathological biopsy can be carried out. The

interpenetration of tongue image diagnosis and gastroscopy forms a dual-image diagnosis mode. The relevant theoretical knowledge needs to be improved. It is not sufficient to support the clinical practice of diagnosis examination of TCM. However, the current researches on chronic gastritis and the objective information of the four TCM diagnostic methods — observation, auscultation and olfaction, interrogation, and palpation and pulse have been gradually developed professionally in-depth. Scholars are exploring more development in the dual-image diagnostic mode.^{19, 20} The syndrome differentiation and the treatment of TCM should be further combined with modern technology to improve the diagnosis of the spleen and the stomach diseases comprehensively. As a result, intervention can be applied at the right time and the prognosis will be improved.

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