Full Length Research Paper

Research on herbal combinations of traditional Chinese medicine for chronic gastritis based on network biology

Peng Lu[1#], Qingqiong Deng[2#], Chenghe Shi[3#], Yibao Gao[1], Jianqiang Yi[1], Mingquan Zhou[2], Yiping Yang[1] and Yuhao Zhao[4*]

[1]Institute of Automation, Chinese Academy of Sciences, Beijing 100190, P. R. China.
[2]College of Information Science and Technology, Beijing Normal University, No. 19 Xin-Jie-Kou-Wai Street, Beijing 100875, China.
[3]Department of Traditional Chinese Medicine, Peking University Third Hospital, Beijing 100191, P. R. China.
[4]School of Traditional Chinese, Medicine, Capital Medical University, 100069, Beijing, P. R. China.

Herbal combinations are important for traditional Chinese medicine physicians to treat diseases. Based on Professor GAO Zhongying's medical records, combination laws are explored in order to study and inherit Professor GAO's academic thoughts and improve the level of clinical treatment from multiple perspectives in treating chronic gastritis. Based on an entropy clustering method of complex systems, Professor GAO's formula data is mined to draw the combinations which have good effects on the treatment of chronic gastritis. Meanwhile, the software Pajek developed for complex network was applied in the process. It not only provides a group of fast and efficient algorithms for to analyze complex networks, but also presents a visual interface to facilitate the understanding on the structural characteristics of complex networks from a visual point of view. Through analyzing the commonness of Professor GAO's formulas, we found the compatibility structure that reflected formula thinking and core clinical features supported the arrangement of Professor GAO's experiences. Through the procedure mentioned earlier, we analyzed and screened 730 formulas in the database and found 30 herbs most frequently used in the treatment of chronic gastritis. By applying the measure of modified mutual information, we got 94 commonly-used herbs with correlation coefficients above 0.05 and through the entropy clustering method of complex systems, we found 11 core combinations. The entropy clustering method of complex systems was used to build the association among 80 herbs commonly used to treat chronic gastritis, and then 122 associations were obtained. We draw out the complex network graph of herbs commonly used for chronic gastritis. These results are completely in line with clinical practices, and they are essentially the commonly used herbs employed by Professor GAO Zhongying for chronic gastritis.

Key words: Herbal combination, chronic gastritis, entropy clustering of complex systems, complex network.

INTRODUCTION

Chronic gastritis is caused by different chronic inflammations of gastric mucosa or atrophic lesions. Besides, chronic gastritis is one of the most common is usually divided into chronic superficial gastritis (CSG)

and chronic atrophic gastritis (CAG). CSG is caused by a digestive diseases; its incidence rate is the highest among the various types of stomach diseases, to account about 80 to 90% of gastroscopy patients. Chronic gastritis variety of chronic inflammation of gastric mucosa superficial, more abdominal pain, fullness after eating, loss of appetite and belching and other bits main symptoms. Unfortunately, there is no effective therapy for CSG in modern medicine.

According to the taxonomy in Traditional Chinese

---

*Corresponding author. E-mail: yuhao.zhao2011@gmail.com.

#These authors contributed equally to this work.

Table 1. Distributions of age and gender.

Type	Frequency	Male	Female	Age
CSG	416	169	247	45.25±7.8
CAG	314	130	184	48.50±8.6

Medicine, CSG belongs to stomach swelling of the liver, stomach category in Traditional Chinese Medicine. On the other hand, CAG is a gastric glands atrophy, mucosal thinning, or with intestinal metaplasia, dysplasia of the pathological features of Digestive Disease Branch of Chinese Medical Association (2006). In western medicine, there exist many treatments including the general, Helicobacter pylori (Hp) eradication, mucosal protective agent, acid, acid-suppressing agents, prokinetic agent therapies and so on for chronic gastritis. The treatment method for Hp-related gastritis has a first-line therapy, second-line treatment, re-called remedial treatment, and sequential therapy.

In Traditional Chinese Medicine, treatment of chronic gastritis achieves a good effect. However herbal combination laws play an essential role in the process of therapy. Therefore, the current research on chronic gastritis is focused to select the appropriate methodology to discover the herbal combination laws. Complex network is one of the methods of data mining which discovers the potential value of the relationship between decision-making, patterns and trends from a large amount of implicit, previously unknown data (Chen et al., 2007). In many cases, data mining is essential to accidentally discovery unexpected and valuable knowledge.

In recent years, complex network is in the stage of development, and models of complex network have been applied in many fields of natural and social sciences. Complex network can be used to describe the social relations among people, the prey species relationships, the topological structures of computer network, semantic relations of words, cooperative relationships of scientists, interactive relations of protein effect, reference relationships of scientific research articles, link relations of webs, and so on.

In conclusion, complex network is used widely from World Wide Web and social network to the food chain and neural system of organisms. Now complex network of qualitative and quantitative study of science has become a major trend. Although, the types of complex network are vastly different, we can use a common model called graph theory to characterize their shared feature. Compared with the complexity of general graph, complex network has a large number of nodes and edges. Therefore, effective and efficient software is required to analyze and simulate complex networks. Pajek can be used for realizing the functions of complex network (Batagelj and Mrvar, 2003). And Pajek, which means

spider in Slavic, not only provides a group of fast and efficient algorithms for analysis of complex networks, but also provides a visual interface that can be more intuitive from a visual point of view to understand the structural characteristics of complex networks. Pajek has a quick calculation, simple visualization and abstract features (Andrew, 2008; Shi et al., 2010). Professor GAO Zhongying has 58 years of experiences in clinical medicine, teaching and research work and especially has contributed to Chinese medicines which treat chronic gastritis.

In order to study and inherit Professor GAO's academic thoughts, and improve the level of clinical treatment, his clinical medication laws are summarized and investigated in treating chronic gastritis from multiple perspectives. By means of entropy clustering method of complex systems and complex network, Professor Gao's formula data is mined, and afterwards we explored the laws of herbal combination in formulas which have good effects in the treatment of chronic gastritis.

MATERIALS AND METHODS

Clinical data

All the medical records of chronic gastritis were collected from Professor GAO Zhongying's recipes in the Dashanlan Clinic and the Dongshi Tenth Road Clinic of Beijing Tong Ren Tang, and the Famous Physician Clinic of Gulou Traditional Chinese Medicine (TCM) Hospital from March 2008 to July 2009. Totally, 730 records were included and all the cases meet the diagnostic criteria for chronic gastritis stipulated in the Guiding Principles of Clinical Studies of New Chinese Drugs in 2002. All the patients were diagnosed as chronic gastritis by measures of endoscopy or biopsy in first class hospitals. In totally, there are 416 chronic superficial gastritis cases and 314 chronic atrophic gastritis cases. The distributions of age and gender are shown in Table 1.

The construction of prescription database

It is necessary to standardize prescription information in order to meet the requirements of data mining. First, the medical named entities of symptoms, signs and checked terms are unified to create the related term specification. Secondly, the terms of diagnosis, syndromes, and therapies are standardized by means of unifying, summarizing and splitting into relatively independent evidences of the meaning of elements in accordance with unified textbooks and finally the related database is created. Thirdly, herbal names are unified by the way of summarizing their categories, functions, natures, flavors and channel tropisms according to the current 21st century curriculum materials. Based on Access database, the structural medical record template is built for Professor GAO

Zhongying clinical diagnosis. The patient information was written into the database in accordance with national standard format. Detailed records of 730 patients were enrolled into Professor GAO Zhongying medical records database in order to discover the knowledge based on entropy clustering method of complex systems and complex network.

Method of data mining

Entropy clustering of complex systems is proposed to mining valued knowledge from formulas. Formula laws can be drawn from the three aspects. The first aspect is referred to the single herb, and it was mainly achieved through the frequency method; the second aspect is referred to the analysis on couplet herbs, mainly through mutual information and association rules, etc., to discuss the commonly used couplet herbs for spleen and stomach diseases; and the last aspect is referred to the combination laws of many herbs, which were discussed through the entropy clustering of complex systems. These three aspects mutually supplemented and corresponded with each other, revealing Professor GAO Zhongying's formula laws together (Shi et al., 2010). The formula database is mined from the multi-levels and multi-dimensions perspectives so that single herb, couplet herbs and many complex herbs are picked up. Compared with the traditional mutual information, the modified mutual information can differentiate positive correlation and negative correlation, and express more positive correlation between couplet herbs.

   The core thought is to relatively punish couplet herbs occurred in formulas. Thus, the information, that the original positive couplet herbs are not lost and the negative couplet herbs are deleted, ensures the efficacy of mining. The principle of modified mutual information is as follows:

Suppose n herbs are expressed with $X_1, X_2, \cdots X_i \cdots X_n$ in which X_i is expressed by

$$X_i = \left(x_i^1, x_i^2, \cdots x_i^j, \cdots, x_i^m\right)$$

. And the probability density functions of herbal X_i are, respectively

$$p(x_i^1), p(x_i^2), \cdots p(x_i^j), \cdots, p(x_i^m)$$

, the joint probability distribution density functions of X_i and X_j are, respectively

$$p(x_i^1, x_j^1), p(x_i^2, x_j^2), \cdots p(x_i^k, x_j^k), \cdots, p(x_i^m, x_j^m)$$

(respectively). Shannon entropy of X_i is shown as formula (1):

$$H(X_i) = \sum_{k=1}^{m} p\left(x_i^k\right) log \left(p\left(x_i^k\right)\right) \tag{1}$$

The joint entropy is expressed as formula (2):

$$H(X_i, X_j) = \sum_{l=1}^{m}\sum_{k=1}^{m} p\left(x_i^k, x_j^l\right) log\left(p\left(x_i^k, x_j^l\right)\right) \tag{2}$$

The mutual information between X_i and X_j is defined as formula (3):

$$I(X_i, X_j) = H(X_i) + H(X_j) - H(X_i, X_j) \tag{3}$$

This formula can be equal to formula (4)

$$I(X_i, X_j) = H(X_i) + H(X_j) - H(X_i, X_j)$$
$$= H(X_i) - H(X_i \mid X_j) \tag{4}$$

Formula (4) depicts the correlations between two herbs, but it could not distinguish positive correlation and negative correlation. Therefore, modified mutual information has been proposed to resolve this problem. Positive-correlative herbs or negative-correlative herbs can be differentiated by using the positive occurrence rate (Chen et al., 2007). The positive occurrence rate is referred to the probability when two variables are 0 at the same time. The positive occurrence rate between positive-correlative herbs is very large, while the occurrence rate between negative-correlative herbs should be 0 theoretically, that is, it is impossible that there are two negative-correlative herbs in a formula at the same time. So, the definition of mutual information and correlation coefficient are anew expressed as:

$$\Delta\mu'(X_i, X_j) = \begin{cases} \dfrac{H(X_i) + H(X_j) - H(X_i, X_j)}{H(X_j)} & Po(i,j) \geq \delta \\ \dfrac{H(X_i) + H(X_j) - 2H(X_i, X_j)}{H(X_j)} & Po(i,j) < \delta \end{cases} \tag{5}$$

Based on entropy clustering of complex systems, correlation coefficients of herbs are computed by the way of the modified mutual information. And the modified mutual information can define positive-correlative herbs that belong to the convergence of the proposed clustering principle to summarize it three-three relevant from two-two positive correlation. The clustering is performed with a fast convergence while the number of classes is not set.

Construction of Chinese herbal complex network

Chinese herbal complex network is constructed by Pajek. This software not only provides a group of fast and efficient algorithms for analysis of complex networks, but also presents a visual interface to facilitate the understanding on the structural characteristics of complex networks from a visual point of view. Through the analysis on the commonness of Professor GAO Zhongying's formulas, we found the compatibility structure that reflected formula thoughts and core clinical features, thus supporting the arrangement of Professor GAO Zhongying's experiences. Complex system entropy clustering method is used to build 80 associations between herbs of Chinese medicine treatment of chronic gastritis and 122 associations are achieved. These data are transformed to the adjacency matrix and this matrix is converted into Pajek format required. Node degrees and edge weights are computed separately by using Pajek 2.0. Node degree is a most simple but most important property in the complex network node properties. The degree of a node is defined as the number of nodes connected to it. Therefore, from an intuitive point of view, the degree of a node indicates that the node is more important. Using Pajek 2.0 Software Layout-Energy-Kamada-Kawai-Separate-Compinents command, the different types of nodes map can be drawn out, combined with manual operation of the node to mediate.

RESULTS

Through analyzing the screened 730 prescriptions from

Table 2. The frequency of herbs.

The herb frequency (sorted index, herb)	
Index	Herb, frequency
1	OS swpiae (OS SEPIAE), 355
2	Trichosanthes, 347
3	Pseudostellaria heterophylla, 324
4	Thunberg fritillary, 300
5	Largehead Atractylodes Rh, 296
6	Fermented Pinellia, 244
7	Rhizoma Zedoariae, 201
8	Gallus gallus domesticus Brisson, 196
9	Amomum villosum, 144
10	Semen Raphani, 142
11	Root of Herbaceous Peony, 126
12	Rhizoma Coptidis, 125
13	Medicinal Evodia Fruit, 116
14	RHIZOMA ZINGBERIS PREPARATA, 94
15	Endothelium Corneum Gigeriae Galli, 80
16	Radix codonopsis,76
17	Semen Arecae Prepareta, 74
18	Angelica, 71
19	Fructus Aurantii Immaturus, 67
20	Ophiopogon japonicus, 61
21	Immature Trifoliate-orange Fruit, 60
22	Cortex Magnoliae Officinalis, 59
23	Bulbus fritillariae cirrhosae, 57
24	Elecampane, 52
25	Salvia Miltiorrhiza, 51
26	Angelica dahurica, 47
27	Baikal Skullcap Root, 47
28	Dioscorea opposita, 44
29	Radix Curcumae, 44
30	Rehmanniae(raw), 38

database, 30 most frequent herbs are use for chronic gastritis after 730 prescriptions were analyzed to screen the database. 30 herbs are shown in Table 2. Based on the modified mutual information, 94 common herbal pairs are obtained and their correlation coefficients are above 0.05. Results are shown in Table 3. 11 core herbal combinations are achieved by using complex system entropy clustering methods, and these results are shown in Table 4. Based on the results of entropy clustering, herbal complex network is constructed by Pajek. It is shown is Figure 1.

DISCUSSION

Results of entropy clustering of complex systems

Formula in TCM was found to be effective in treating disease (Jianxin et al., 2011; Jianxin et al., 2011). The mining of its herbal combination rules play a key role in understanding its action mechanism. Traditional statistics and data mining methods are hardly used to make a distinctions between positive correlation and negative correlation because Chinese medicine prescriptions often have the characteristics of high dispersion degree and nonlinear and so on (Selecting Biomarkers for Primary Hyperlipidemia and Unstable Angina in the Context of Neuro-endocring-immune Network by Feature Selection Methods, 2010). The complex system entropy clustering method is proposed to use to be appropriate for data characteristics of TCM clinical four diagnostic methods and Chinese medicine prescriptions. It is a kind of unsupervised data mining methods and accords with the non-linear relation among the graded variable such as four diagnostic information. And the variables are clustered by self-organization, and the variable number in each cluster is automatically determined. Through the methods mentioned above, we analyzed and screened

Table 3. Couple-herb and its correlation coefficient.

Index	Couple-herb, mutual information
1	Rhizoma Coptidis, Medicinal Evodia Fruit, 0.64031
2	OS swpiae (OS SEPIAE), Thunberg fritillary, 0.19216
3	Endothelium Corneum Gigeriae Galli, Radix Trichosanthis, 0.17318
4	Trichosanthes,OS swpiae (OS SEPIAE), 0.14874
5	Tortoise Shell, Drgonsbones, 0.14749
6	Tortoise Shell, Oyster, 0.14749
7	Lignum Dalbergiae Odoriferae, Kaempferia galanga, 0.13394
8	Semen Arecae Prepareta, elecampane, 0.13394
9	RHIZOMA ZINGBERIS PREPARATA, Amomum villosum, 0.12569
10	Largehead Atractylodes Rh, Rehmanniae (raw), 0.11946
11	Largehead Atractylodes Rh, Baikal Skullcap Root, 0.11214
12	Milkvetch root, Pseudostellaria heterophylla, 0.11102
13	Rehmanniae (raw), Rehmanniae (prepared), 0.10788
14	Rehmanniae (raw), Baikal Skullcap Root, 0.1005
15	Angelica, Endothelium Corneum Gigeriae Galli, 0.096696
16	Angelica, angelica dahurica, 0.096696

Table 4. The core herbal combinations.

Index	Herbal combinations
1	Pseudostellaria heterophylla, Largehead Atractylodes Rh, OS swpiae (OS SEPIAE), Thunberg fritillary and Trichosanthes
2	Pseudostellaria heterophylla, Largehead Atractylodes Rh, Endothelium Corneum Gigeriae Galli, Trichosanthes and Thunberg fritillary
3	OS swpiae (OS SEPIAE), Thunberg fritillary, Rhizoma Coptidis and Medicinal Evodia Fruit
4	Angelica dahurica, Lignum Dalbergiae Odoriferae, elecampane and Kaempferia galanga
5	Endothelium Corneum Gigeriae Galli, OS swpiae (OS SEPIAE), Rhizoma Coptidis and Medicinal Evodia Fruit
6	Trichosanthes, OS swpiae (OS SEPIAE),Rhizoma Coptidis and Medicinal Evodia Fruit
7	Thunberg fritillary, OS swpiae (OS SEPIAE) and Trichosanthes
8	Largehead Atractylodes Rh, Rhizoma Zedoariae and Pseudostellaria heterophylla
9	Largehead Atractylodes Rh, Baikal Skullcap Root and Pseudostellaria heterophylla
10	Fermented Pinellia, OS swpiae (OS SEPIAE) and Trichosanthes
11	Endothelium Corneum Gigeriae Galli, OS swpiae (OS SEPIAE) and Trichosanthes

730 formulas in the database, and found most frequent 30 herbs used in the treatment of chronic gastritis. By applying the method of modified mutual information, we got 94 commonly-used herbs with correlation coefficients of above 0.05; and through entropy clustering method of complex systems, we found 11 core combinations.

Entropy clustering method of complex systems was used to build the associations among 80 herbs commonly used to treat chronic gastritis, and 122 associations were obtained. We draw out the classified graph of complex network of herbs commonly used for chronic gastritis. According to statistics, cuttlebone had the highest frequency of OS swpiae (OS SEPIAE) 355, Radix Trichosanthis 347, Heterophylla falsestarwort 324, Thunberg fritillary 300, Largehead Atractylodes Rh 296, Fermented Pinellia 244, Rhizoma Zedoariae 201, Gallus gallus domesticus Brisson 196, Amomum villosum 144, Semen Raphani 142, Root of Herbaceous Peony 126,
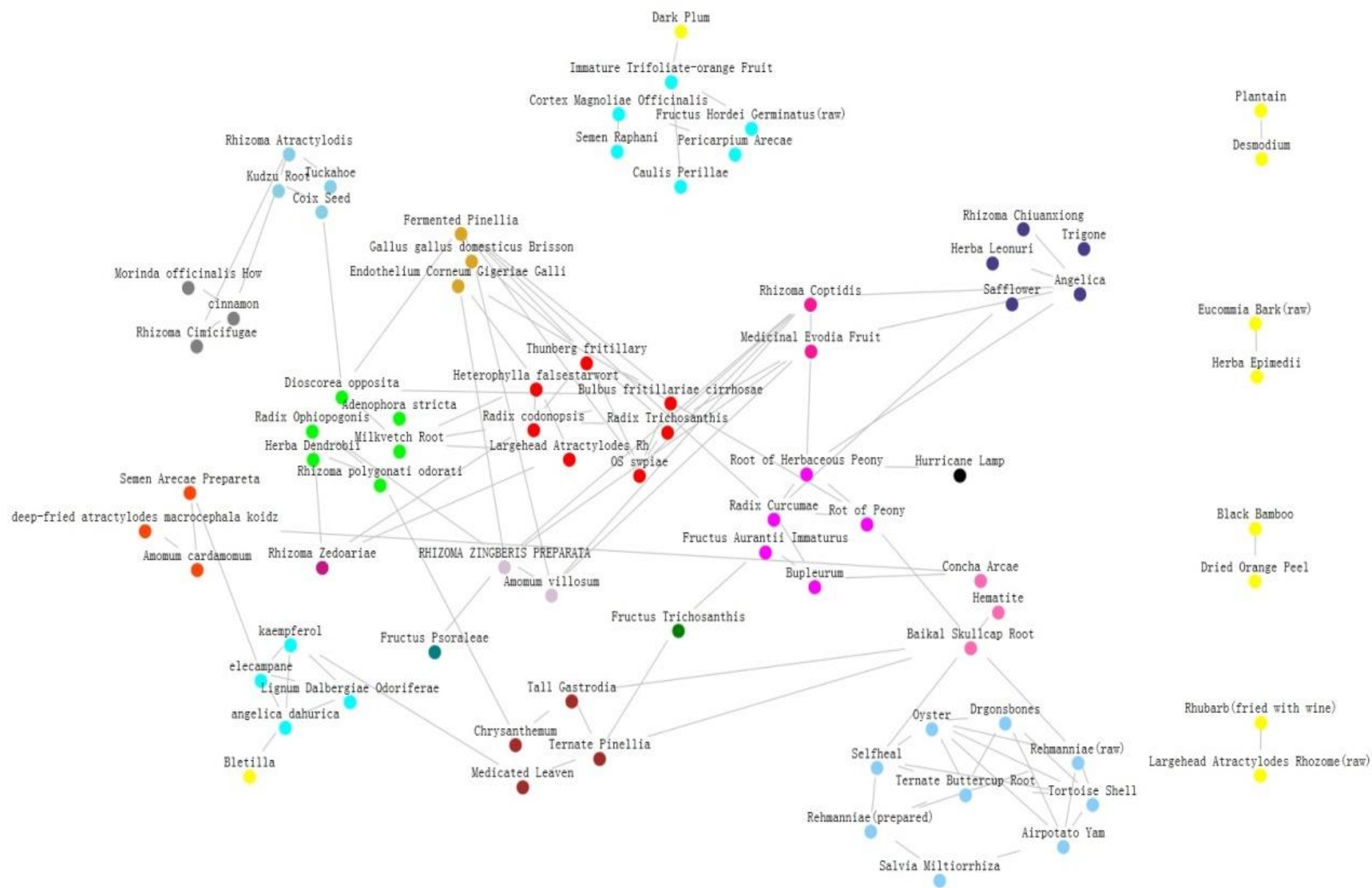
Figure 1. Herbal complex network node categories for chronicgastritis.

Rhizoma Coptidis 125, Medicinal Evodia Fruit 116, Rhizoma Zingberis Preparata 94 and Endothelium Corneum Gigeriae Galli80. The results completely conform to clinical practice, and basically they are the common herbs for treatment of chronic gastritis, with basically uniform with core combination data reflected in Table 3. And they are essentially Professor GAO Zhongying's commonly used herbs for chronic gastritis.

Results of complex network

Complex network is an effective method to associate diverse kinds of information. The core prescription combinations are selected to reflect the experiences of famous physicians by means of analyzing the graph structures of entropy clustering result.

The major core herbal combination in complex network

The major herbal combination has Heterophylla false starwort (Radix codonopsis), Largehead Atractylodes Rh, Radix Trichosanthis, Thunberg fritillary (Bulbus fritillariae cirrhosae), OS swpiae (OS SEPIAE). Largehead Atractylodes Rh is mainly used to maintenance spleen; Radix Trichosanthis, Thunberg fritillary (Bulbus fritillariae cirrhosae), OS swpiae (OS SEPIAE) are used to repair erosions of stomach. The compatibility of core herbal combination reflects the key pathogenesis of spleen deficiency and stomach dryness for chronic gastritis. Compatibility mechanism of the herbal combination shows the core pathogenesis of spleen deficiency and stomach dry for chronic gastritis. This combination can be used either for chronic superficial gastritis or chronic atrophic gastritis.

The secondary core herbal combinations in complex network

The secondary core herbal combinations surround the major core herbal combination in complex network. These combinations are categorized in four groups. The first group is Zuojin pill composed of Medicinal Evodia Fruit and Rhizoma Coptidis. And its function is to treat heartburn, acid reflux embolism. Endothelium Corneum Gigeriae Galli, Fermented Pinellia and Gallus gallus domesticus Brisson can be added in order to promote gastric motility to help to digest. This five-herb combination can be used to cure spleen deficiency and stomach dry of chronic superficial gastritis or gastroesophageal reflux disease. The second group is Sini powder composed of Bupleurum, Radix Curcumae, Rot of Peony, Root of Herbaceous Peony and Fructus Aurantii Immaturus. It has the efficacy of liver and gallbladder.

In clinical treatment, it is used for incompatibility of liver and stomach, incompatibility of gall bladder and stomach such as cholecystitis. The third group is Zhang Xichun's Yuye soup which is composed of Adenophora stricta, Ophiopogon japonicus, Rhizoma polygonati odorati, Dioscorea opposita, Herba Dendrobii and Milkvetch root. Its core functionality is to strengthen spleen, invigorate Qi, stomach and promote fluid. This combination can be used to cure spleen deficiency and stomach dry of chronic superficial gastritis. With intestinal metaplasia or dysplasia, Salvia Miltiorrhiza and Rhizoma Zedoariae must be added to promote blood circulation and remove stasis. The fourth group includes Rhizoma Zingberis Preparata and Amomum villosum. It is used to cure hypofunction of Yang and deficiency and coldness of spleen. With diarrhea, Fructus Psoraleae, Gorgon fruit and Lotus meat must be added.

Basic experience prescription of chronic gastritis

Combining the above result of complex network with clinical practice, experience formula is summed up as follows:

1. The basic formula for chronic superficial gastritis Heterophylla falsestarwort (Radix codonopsis), Largehead Atractylodes Rh, OS swpiae (OS SEPIAE), Thunberg fritillary (Bulbus fritillariae cirrhosae), Radix Trichosanthis, Gallus gallus domesticus Brisson, Endothelium Corneum Gigeriae Galli and Fermented Pinellia.
2. The basic formula for chronic atrophic gastritis, Heterophylla falsestarwort (Radix codonopsis), Largehead Atractylodes Rh, OS swpiae (OS SEPIAE), Thunberg fritillary (Bulbus fritillariae cirrhosae), Radix Trichosanthis, Adenophora stricta, Ophiopogon japonicas, Rhizoma polygonati odorati, Dioscorea opposite, Herba Dendrobii and Milkvetch root.
3. Basic formula addition and subtraction herbal laws; The prescription adds Medicinal Evodia Fruit and Rhizoma Coptidis accompanying with gastroesophageal reflux. If this reflux becomes severe, Concha Arcae, Inula flower and Hematite are added into this formula. If erosion or ulceration of stomach appears, Bletilla and Angelica dahurica are added and Bupleurum, Radix Curcumae, Fructus Aurantii Immaturus (Immature Trifoliate-orange Fruit) and Root of Herbaceous Peony are added when bile reflux. Rhizoma Zingberis Preparata and Amomum villosum are added if stomach cold becomes severe and pale tongue appears. Fructus Psoraleae, Gorgon fruit and Lotus meat are added if diarrhea appears.

Conclusion

Herbal combination laws are essential to treat the

diseases for traditional Chinese medicine. In this paper, we explore Professor GAO Zhongying' experiences that they are reflected in his formulas of the treatment for chronic gastritis. And then entropy clustering and complex network are adopted in the process of discovering knowledge of herbs. The results show that herbal combinations are completely in line with clinical practices, and they are essentially the commonly used herbs employed by Professor GAO Zhongying for chronic gastritis.

ACKNOWLEDGEMENTS

REFERENCES

Andrew LH (2008). Network pharmacology: the next paradigm in drug discovery, Nat. Chem. Biol., 4(11): 680-690.
Batagelj V, Mrvar AP (2003). Analysis and Visualization of Large Networks. in Junger, M., Mutzel, P., (Eds.) Graph Drawing Software. Springer, Berlin, pp. 77-103.
Chen JX, Xi GC, Chen J, Zhen YS, Xing YW, Wang J, Wang W, (2007). An unsupervised pattern (syndrome in Traditional Chinese Medicine) discovery algorithm based on association delineated by revised mutual information in chronic renal failure data, J. Biol. Syst., 15: 435-451.
Digestive Disease Branch of Chinese Medical Association (2006). Chinese consensus on chronic gast, Chin. J. Gastroenterol., 11: 674-679.
Jianxin C, Huihui Z, Ying Y, Bing L, Jian N, Wei W (2011). Lipid-lowering and antioxidant activities of Jiang-Zhi-Ning in Traditional Chinese Medicine, J. Ethnopharmacol., 134: 919-930.
Jianxin C, Xueling M, Huihui Z, Ying Y, Jing H, Shuzhen G, Bing L, Jian N, Wei W (2011). Biological effects based quality control of a traditional Chinese medicine, J. Med. Plants Res., 5(31): 6895-6906.
Selecting Biomarkers for Primary Hyperlipidemia and Unstable Angina in the Context of Neuro-endocring-immune Network by Feature Selection Methods (2010). J. Bio. Syst., 18(3): 605-619.
Shi CH, Wang XJ, Chen JX, Liu RQ, Zhao YH, Yang HJ (2010). Complex system entropy cluster famous and old TCM physicians' experiences chronic gastritis (spleen deficiency and stomach dryness) drug selection law, J. Trad. Chin. Med., 30(4): 294.