CASE REPORT

Diabetes with pyogenic liver abscess—A perspective on tongue assessment in traditional Chinese medicine

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Summary

\textbf{Background:} This novel study provides a time series analysis of tongue features extracted from a diabetic patient with pyogenic liver abscess (PLA), treated with the integration of western medicine and traditional Chinese medicine (TCM). The features, namely, tongue color, tongue fur thickness and fur color, identified from a series of tongue images taken every two days, exhibit significant transitions matching closely with the progression of disease. These tongue features could serve as effective, non-intrusive indices for different progression stages of diabetes with PLA.

\textbf{Case presentation:} A 76-year-old male diabetic patient was admitted for hyperglycemic hyperosmolar state. Intermittent fever and abdominal discomfort were noted. After performing abdominal computed tomography and laboratory studies, the results indicated pyogenic liver abscess, \textit{Klebsiella pneumoniae} ssp. \textit{pneumoniae} related. As PLA progressed, the patient suffered spiking fever and right upper abdominal pain. Tongue examination revealed features with red tongue, white-yellow and thick fur. After receiving pigtail catheter drainage, the fever subsided and the pus-like fluid was drained smoothly. During the course of this process, gradually dwindled tongue fur witnessed through periodic tongue examination coincides consistently with laboratory data, namely, body temperature, fasting plasma glucose and plasma glucose level gathered.

\textbf{Conclusion:} This is the first time series analysis of applying tongue examination to the progression of a specific disease. Through a series of tongue images taken periodically, tongue color, tongue fur thickness and fur color are identified to closely linked to the progression of diabetes.
with PLA, as indicated by data gathered through means of plasma glucose and abdominal sono-
graphic follow-ups. Based on this promising finding, our future study will further extend the
application of tongue assessment to evaluate the tongue characteristics of diabetic patients.
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Introduction

As the world population increases rapidly, diabetes mellitus (DM) has become the major burden of adult public
health. According to an epidemiological study of the global
prevalence of diabetes,1 there were 171 million people
with diabetes worldwide in 2000. This figure is expected
to keep increasing to 366 million by 2030. Among the risk
factors relating to pyogenic liver abscess (PLA), e.g., dia-
betes, malignancy, renal disease and pneumonia, diabetes
ranks first as the primary risk factor. PLA is associated
with a poor prognosis for diabetic patients than other
patients.2 PLA is a rare, life-threatening disease with an
increasing rate of incidence.2 Previous studies indicated
the prevalence of PLA increased among the population
in eastern Asia, especially in Taiwan. PLA is regarded as an
endemic disease in public health issues in Taiwan.4 These
reports pointed out that diabetes is the main pre-
disposing factor of liver abscess and Klebsiella pneumonia
the primary pathogen.4 For patients with K. pneumonia
liver abscess, an appropriate antimicrobial treatment com-
bined with percutaneous drainage of liver abscesses is
approved.5

Tongue assessment plays an important role in TCM.6 The
tongue is connected to the internal organs through meridi-
ans; thus the conditions of organs, qi, blood, and body fluids
as well as the degree and progression of disease are all
reflected on the tongue.7 Organ conditions, properties and
variations of pathogens can be revealed through observa-
tion of tongue. For example, changes in the tongue
primarily mirror organ status and the flow of qi and blood;
variations in tongue fur can be employed to determine the
impact of exogenous pathogenic factors and the flow of
stomach qi. Tongue fur color and thickness were found to be
associated with effective response in specific disease.8 Bucc-
al alterations can be easily observed in diabetic patients
with an inadequate glycemic control.9 In clinical practice,
practitioners observe tongue characteristics, such as the
color and shape, and the amount of saliva before deduc-
ing the primary ailment of a patient. However, observation
assessment is often biased by subjective judgment, originat-
ing from personal knowledge, experience, thinking patterns,
assessment skills, and color perception or interpretation.
There are no precise or existing quantifiable standards.
Different practitioners may pass varying judgments on the
same tongue, while a practitioner may even reach different
assessments on the identical tongue if examined at different
time. Such inconsistency leads many people to be skepti-
cal of TCM, which motivated us to develop the Automatic
Tongue Diagnosis System (ATDS).10 ATDS has demon-
strated high degree of assessment agreement far-surpassing
human counterparts.11 It is expected that ATDS can assist TCM prac-
titioners to establish reliable assessments by providing them
with standardized automatic procedures as well as objec-
tive, reliable and quantified data. The aim of this study is
to establish representative indices on different progression
stages of diabetic with PLA through periodic observation and
analysis of tongue by ATDS.

To the best of our knowledge, there is no references
surveyed applying temporal analysis to a series of tongue
images to observe transitions in tongue characteristics. The
subject, infected with poorly controlled DM, further compi-
lcated by PLA, was treated with the integration of western
medicine and TCM throughout the progression of the dis-
ease without further complication such as endophthalmitis
or meningitis.

Case presentation

Hospital stay

This 76-year-old male patient, with the past history of
diabetes mellitus and hypertension, was admitted due to
shortness of breathing and general weakness persistent for
one day. Dyspnea, thirst sensation and poor appetite were
also mentioned. Laboratory data showed hyperglycemia
(random plasma glucose level: 689 mg/dL) and urine exami-
nation indicated no ketone body, ref. Table 1. Arterial blood
gas showed hypoxemia but no acidosis. The patient was
admitted for further care under the impression of Type 2
DM with hyperglycemic hyperosmolar state.

During hospital stay, the hyperglycemic status was not
well-controlled by continuous IV insulin infusion. Intermit-
tent fever and abdominal discomfort were noted. Abdominal
computed tomography (CT) was performed, which revealed
liver abscess (Fig. 1), and blood culture showed K. pneu-
monia. Ceftibuten 2 g at bedtime and metronidazole 500 mg
every 6 h were administered intravenously. He was diag-
nosed with pyogenic liver abscess, K. pneumoniae ssp.
pleumoniae related, accompanied with hyperglycemia.
Whole body Ga-67 scan was arranged to rule out endoph-
thalmitis or meningitis, and the result revealed infectious
process at segments VI and VII of liver. Standard treat-
ment included percutaneous needle aspiration or pigtail
catheter drainage and combination antimicrobial therapy
for 2–4 weeks. He later received percutaneous transhepatic
needle aspiration and antibiotic therapy. Abdominal ultra-
sound was scheduled to evaluate the size of liver abscess
and needle aspiration was performed in the case of ligue-
ried abscess. On the 9th day, he developed spiking fever
up to 39 degrees and persistent abdominal pain, percu-
taneous transhepatic abscess drainage was subsequently
performed and antibiotics changed to cefotaxime 2 mg
evory 6 h and metronidazole 500 mg every 6 h administered
intra-
venously. His clinical condition improved gradually and fever
subsided. After several rounds of abdominal sonographic
follow-ups, drainage catheter was removed on the 19th day
and antibiotic switched to ceftibuten 200 mg orally every
12 h because the volume of abscess cavity dwindled and total
daily drainage from the catheter decreased to less than 5 ml
for three consecutive days. The blood sugar level stabilized and insulin regimens shifted to oral anti-diabetic drugs. In consideration of no more complication occurred, the patient was later discharged.

Integration of western medicine and tongue assessment

During hospital stay, physical examination, namely, body temperature, pulse rate and respiration rate, were checked every 8 h. Other items, e.g., fasting plasma glucose and plasma glucose (A.C.), were recorded every day. At the same time, tongue assessment through ATDS was performed every 2 days and herbal medicine was prescribed based on the result of examination. For every tongue image taken, distinguishing characteristics employed in tongue assessment were extracted automatically by ATDS, such as tongue color, tongue fissure, fur color, fur thickness, ecchymosis, tooth mark, red dot, saliva, and tongue shape, to further generate detailed information regarding length, area, moisture, and number of fissures, marks, and dots, as shown in Fig. 2. Based on the suggestions of TCM doctors participating in this investigation, ATDS selects 9 primary tongue features, including tongue color (slightly white, slightly red, red, pink red, dark red, dark purple), fur color (white, white-yellow, yellow, dye), fur thickness (none, thin, thick), saliva (none, little, normal, excessive), tongue shape (thin and small, moderate, fat and large), tongue fissure, red dot, ecchymosis, and tooth marks (the last four are divided into categories of none, mild, moderate, and severe), for the time series analysis.

Clinical findings

Transitions of body temperature and plasma glucose

The most common clinical manifestations in patients with PLA are fever, chills, and abdominal pain. Although the patient received antimicrobial therapy, yet intermittent fever and abdominal pain persisted. As PLA progressed, he suffered spiking fever and right upper abdominal pain on D9. After receiving pig-tail catheter drainage, the fever subsided and the pus-like fluid was drained smoothly on D12. Gradually, a temperature was reached after D12, as shown in Fig. 3.

 Plasma glucose level was examined for 4 times a day. A higher level of plasma glucose (567 mg/dl) was observed on D9 as PLA progressed. The corresponding hyperglycemic status was not well-controlled by insulin injection pump and antibiotics before pig-tail catheter drainage was performed. As the infectious condition steadily improved, the plasma glucose gradually stabilized at a lower level after D12, ref. Fig. 4.

Transitions of sonography of pyogenic liver abscess

Abdominal sonography showed size of main liver abscess about 8.87 cm × 8.64 cm in the liver S7-8 on D3. Percutaneous aspiration and combination antimicrobial therapy were performed subsequently. As PLA progressed and matured, the patient’s condition improved gradually and

<table>
<thead>
<tr>
<th>Hematology</th>
<th>Blood chemistry</th>
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<tr>
<td>WBC 17.4 × 10^3/ml</td>
<td>Creatinine 0.92 mg/dL</td>
</tr>
<tr>
<td>RBC 3.38 × 10^3/ml</td>
<td>Urea nitrogen 28 mg/dL</td>
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<tr>
<td>Hb 10.1 g/dl</td>
<td>Na 133 mEq/L</td>
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<td>Hct 29.5 %</td>
<td>K 4.7 mEq/L</td>
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<tr>
<td>MCV 87.5 fl</td>
<td>Mg 2.2 mEq/L</td>
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<tr>
<td>Platelet 243 × 10^3/cumm</td>
<td>P 3.5 mEq/L</td>
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<tr>
<td>Neutrophil-seg 87.4 %</td>
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<td>Lymphocyte 8.7 %</td>
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<td>Monocyte 3.8 %</td>
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<td>Eosinophil 0.1 %</td>
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Table 1 Laboratory data on consultation day (2012.02.06, D1).
Figure 2  Nine primary tongue features automatically extracted by ATDS.

Figure 3  The fluctuations of body temperature. As PLA progressed, the patient suffered spiking fever and right upper abdominal pain on D9. After receiving pig-tail catheter drainage, the fever subsided and the pus-like fluid was drained smoothly on D12.

Figure 4  The changes in Plasma glucose level. The patient's hyperglycemic status was not well-controlled under infectious condition. After receiving pig-tail catheter drainage on D9 with plasma glucose was 567 mg/dl, his plasma glucose gradually stabilized after D12.
the abscess size reduced slightly to 8.74 cm × 8.64 cm on D11 after receiving catheter drainage. Eventually, drainage catheter was removed on D19 because the size of PLA decreased and abscess drainage less than 5 ml for successive three days. The liver abscess size about 4.71 cm × 4.18 cm was observed on D23, as shown in Fig. 5.

Transitions of tongue characteristics

A series of tongue images were taken every two days. All images were analyzed by ATDS and relevant features, namely, tongue color, tongue fissure, fur color, fur thickness, ecchymosis, tooth mark, red dot, saliva and tongue shape, were extracted. The tongue images taken on D1, D10, D19, and D23 are shown in Fig. 6. The corresponding tongue features extracted are also included.

On D1—D8, the tongue examination showed pink red tongue, yellow tongue fur, thick fur distributed over the tongue root. As PLA progressed, the patient suffered spiking fever and right upper abdominal pain on D9. This was immediately reflected on tongue color changing to red on D10. After receiving pig-tail catheter drainage, the fever subsided and the pus-like fluid was drained smoothly on D12. Tongue color returned to normal pink-red on D15.

Additionally, obvious changes in fur color and thickness were observed. Fur color changed sequentially from yellow to white-yellow on D10, and then to white on D15. However, fur thickness did not have a dramatic change during D1—D19. Thick fur was related to the phlegm-dampness pattern. Tongue fur was distributed all over tongue surface on D10—D15. Fur distribution and root fur correspond to the pathogen distributed on triple energizers (upper, middle, or lower energizers). The tongue fur gradually reduced as the patient’s symptoms improved. Based on the tongue features observed, Huopu-xialing decoction was prescribed to reduce the dampness-heat assailing the exterior. Thick fur was gradually reduced until D21. The changes in tongue and fur characteristics, as observed through a series of tongue examination, are summarized in Table 2.

Discussion

The core of assessment in Chinese Medicine is “pattern identification/syndrome differentiation and treatment” with inspection, listening and smelling examination, inquiry, and palpation as the bases. Inspection tops the four assessments, and tongue assessment is a crucial part during observation. Observation of the tongue, also known as tongue assessment, is an important procedure in assessment by inspection. The tongue appearance is a crucial indicator in the assessment of the physiological and pathological changes of internal organs in the body.

Studies have shown that tongue assessment plays an important role in clinical prognosis and treatment. The tongue is connected to the internal organs through meridians; thus the conditions of organs, qi, blood, and body fluids as well as the degree and progression of disease are all reflected on the tongue. Organ conditions, properties, and variations of pathogens can be revealed through observation of tongue. Tongue inspection refers to the shape, color, and fur color, fur thickness, and other characteristics. For instance, red tongue is closely related to the fire-heat pattern and the yin deficiency pattern, while a faint white tongue is connected with the phlegm-dampness pattern.
Figure 6  Tongue image series (a) D1. Pink-red tongue color, yellow thick fur, (b) D10. Red tongue color and white-yellow, thick fur, (c) D19. Pink-red tongue color and obviously reduced tongue fur, mainly distributed on the posterior segment, (d) D23. Normal pink-red tongue color, white and thin fur, corresponding to tongue features of a healthy person, and (e) The corresponding tongue features extracted. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Table 2  Tongue shape, tongue color, fur color, fur thickness, fur distribution and fur root, extracted from a series of tongue images taken every two days, are listed. This data serves as the basis to evaluate the changes in tongue as the progression of disease.

<table>
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<tr>
<th>Tongue characteristics</th>
<th>Fur characteristics</th>
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<tr>
<td></td>
<td>Tongue shape</td>
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<tr>
<td>D1</td>
<td>Moderate</td>
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<td>Moderate</td>
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<td>D5</td>
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<td>D21</td>
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<td>D23</td>
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According to TCM theory, red tongue was closely linked to the heat pattern, as evidenced by the corresponding spiking fever. Thin fur is associated with the Wind and fire-heat pattern, and thick fur is usually linked to the phlegm-dampness and blood stasis patterns. 

For this diabetic patient with PLA, the transitions of tongue coating, location, and coating color, thickness closely match the progression of the disease. These tongue features can be utilized to predict the progression of diabetes with PLA. The tongue fur thickness is further divided into none fur, thin fur, and thick fur. None fur is literally the absence of tongue coating, and the criterion to differentiate between thin and thick fur hinges on whether the tongue quality lying below is visible. Moreover, there was no common agreement regarding the classification of tongue fur thickness in the past. To circumvent this deficiency, a quantitative definition of thick fur is given in this study. Thick fur is defined as the tongue fur making the underlying tongue quality invisible and occupying more than two thirds of the total tongue area. We found the tongue fur changed dramatically as disease progressed, such as thick fur in the posterior surface at hyperglycemia, thick fur covering the whole surface at spiking fever, and thin fur after recovery. According to the TCM theory, tongue fur indicates the state of the Yang organs, especially the digestive system. Our finding indicates that the tongue assessment could potentially serve as an indexing means for disease prognosis, such as rheumatoid arthritis and diabetes. More future research efforts will focus on this efficient, non-intrusive and important direction.

Inevitably, traditional tongue assessment does have its limitations attributable to both practitioner’s skill and environmental setting. Not only the clinical skill involved in tongue assessment depends highly on the clinician’s experience and knowledge, but also the environmental factors influence significantly on the assessment results. According to the study on the agreement on tongue assessment, poor intra-observer agreement is still manifested even if the TCM doctors were well trained. Therefore, it is necessary to establish an objective standard for tongue assessment. We regularly collected and displayed standard photographs to teach the TCM doctors to improve both the intra- and inter-agreement of tongue assessment. The standard operating procedure of tongue assessment is proposed and detailed guidelines are followed to enhance the assessment agreement among TCM clinicians, as shown in Fig. 7. As a result, the study suggests that tongue assessment is potentially useful for treatment progress in diabetic patients both for TCM and conventional medicine interventions.

**Conclusion**

This is the first time-series analysis of applying tongue examination to observe disease progression. The features, namely, tongue color, tongue fur thickness and fur color, extracted from a series of tongue images taken every two
days, exhibit significant changes that match closely with the progression of disease. These features could serve as indices for different stages of diabetes with PLA. Future endeavors will focus on the application of tongue assessment to evaluate the tongue characteristics of diabetic patients.

Acknowledgements

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References