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Original Article

Predicting the prognosis of Conservative Treatment in Acute Cholecystitis using an Artificial Neural Network

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ABSTRACT

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Introduction: In majority of the cases clinicians usually choose the conservative mode of treatment as the first line of treatment in case of acute cholecystitis. But studies have shown that in most of the cases patients do not show any significant improvement and eventually are referred to cholecystectomy. This delay in referral catalyses complications like septic conditions and development of gangrenous cholecystitis. Computational structures like artificial neural networks are excellent tools for predicting outcomes apriori. So a neural network was employed to predict the prognosis of conservative treatment mode in cholecystitis and avoid the otherwise imminent complications.
Materials and Methods: A neural network was developed and trained on clinically significant data from a set of 150 medical records pertaining to patients who presented themselves with diagnosis of acute cholecystitis at a tertiary care hospital. The performance of the network was tested on this training set and a separate validation set comprising of data from 100 such patients.
Results: The developed network demonstrated excellent prognostic capabilities with respect to the success/failure of conservative treatment in acute cholecystitis.
Conclusion: A neural network can predict the outcome of conservative treatment in cholecystitis with significant accuracy and could prove to be an indispensable tool to clinicians.

Keywords: Cholecystitis, Artificial Neural Network, Conservative

INTRODUCTION

Pathophysiology of acute cholecystitis is cystic duct obstruction, which results in acute sterile inflammation. This is usually followed by secondary bacterial infections of gallbladder.[1] Clinicians based on their clinical experience and medical acumen choose between two treatment options: Early cholecystectomy and Conservative treatment with antibiotics.[2] In this part of the world due to economic, logistic and administrative reasons coupled with tremendous overload of healthcare facilities the first line of treatment in acute cholecystitis in majority of the cases is the conservative mode of treatment. The treatment regimen in conservative mode comprises of broad-spectrum antibiotics, bowel rest and interval cholecystectomies 6-8 weeks later. In patients who are considered poor surgical candidates, conservative mode remains the preferred option. However, studies have shown that a significant portion of patients does not respond to the conservative mode of treatment. This delay in "conservative-mode" catalyses complications like septic conditions and development of gangrenous cholecystitis.[3]

With advent and advances in the branch of computational medicine, various investigators have employed computational techniques in almost every field of medicines for the purposes of diagnosis, prognosis, dosage monitoring and other chaotic complex clinical problems. When it comes to pattern finding and decision making in unclear clinical problems, the computational structures known as "Neural-Networks" are the best candidates. These are computational structures capable of parallel information processing, mimicking domain experts and these structures excel in hidden pattern finding. The performance of such structures could be improved by training them on expert domain knowledge.[4,5]

Aims and Objectives

1. To develop an Artificial Neural Network that could possibly predict the success/failure of the conservative mode of treatment in acute cholecystitis.
2. To assess the prognostic capabilities of the developed Neural Network.

MATERIALS AND METHODS

We perused the medical records from the Medical Records Department of a tertiary care hospital of all the patients who attended the department of surgery with the diagnosis of acute cholecystitis during the period 1 June 2012 to 31 Dec 2014.We recorded all the vital laboratory investigations, imaging studies and symptoms on presentation. In consultation with an attending surgeon we came up with the cardinal symptoms of cholecystitis on presentation. This set of parameters was divided into three subsets-Demographic parameters, clinical parameters and Imaging parameters. Patients were divided into two sets: those who responded to conservative mode of treatment labelled as CTR (+) and those who did not show any significant improvement and were subsequently referred for cholecystectomy labelled as CTR (-).

Development of Neural -Network

A general regression neural network was used in the development of the predictive model.[6] It was developed as a 3-layered structure: an input layer, a hidden layer and an output layer. The input variables were formed by the number of elements in the set of cardinal symptoms on presentation. The intervening neuron layers called the hidden layer detect higher order patterns in input layer, analyse the signal and relay the output to other neurons to make a correct output. As the general regression neural network requires one neuron per pattern processed, the number of neurons in the hidden layer are determined by the number of patterns in the training set. The output from this network provided the likelihood of the success/failure of the conservative mode of treatment. The patient population record set consisted of 250 records, out of which data from 150 patient records was used as the training set for the developed neural network and the remaining 100 patient records comprised the validation set. For the purposes of cross-validation the data in the derivation set was subdivided by a random number generator into 10 subsets.[7] Nine of Ten subsets were used for training. The data from the 10th subset was used as an evaluation set during training. The entire training course was repeated nine additional times by rotating the training evaluation set. All independent parameters were scaled between a value of 0 and 1.

Prognostic capability of the neural network

To evaluate the prognostic capabilities of the neural network complete sensitivity and specificity analysis was performed on the validation set. Corresponding Confidence intervals and statistical significance (p-values) were also calculated.

RESULTS

The medical parameters of the training set were divided into three sub-sets: demographic data (Table 1), clinical parameters on presentation (Table 2), biochemical, and sonographic results (Table 3). In total 10 neural networks were trained and were structured to produce output values between 0 and 1. Where output 0 signified failure if a patient is treated conservatively and output 1 signified that patient would respond well to the conservative mode of treatment. The average mean squared error for all the trained neural networks was 0.008899. The neural network with the closest mean squared error to the average was selected for further analysis.

Table 1: Demographic Data

	CTR(-) (n=47)	CTR(+) (n=103)
Age(Years)	50-87	18-87
Age > 70	26	27
Diabetes	19	11

CTR (-)=Patients who didn't respond to conservative treatment
CTR (+) =Patients who responded to conservative treatment.

Table 2: Clinical variables on presentation

Test	CTR(-) (n=47)	CTR(+) (n=103)
Pain(Days)	0.5-7	0.5-30
AT(Mild)	10	21
AT(Moderate)	24	54
AT(Severe)	13	28
BP(Systolic)	85-188	90-180
BP(Diastolic)	52-95	49-120
Heart rate(bpm)	55-130	50-112

AT=Abdominal Tenderness, BP=Blood Pressure
bpm=Beats per minute

Table 3: Presenting vitals in the two groups

	CTR(-) (n=47)	CTR(+) (n=103)
WBC(103 cells/µl)	25	12
WBC>15000 cells/µl	26	16
ALT IU/l	2-348	3-882
AST IU/l	14-284	16-520
ALK p IU/l	12-920	42-464
GGT IU/l	19-1193	9-1250
Amylase IU/l	31-1618	30-2520
Total bilirubin mg/dl	2.5-75	2-420
Sonography(Abdomen)		
Gall Stones(small)	25	69
Gall Stones(Single)	14	29
Gallbladder(>5cm Dia)	40	35

The chosen network achieved a sensitivity of 100 %(95%CI, 92.45% to 100.00%) and a specificity of 75.73 %(95%CI, 66.29% to 83.64%) with corresponding p-value<0.001.

The performance of the neural structure was tested prospectively on the medical data from the validation set comprising of medical records of 100 patients. In this set 12 patients belonged to the group labelled as CTR (-) and the remaining 88 belonged to the group labelled as CTR (+). In case of this validation group the neural structure achieved a sensitivity of 100 %(95%CI, 73.54% to 100.00%) and a specificity of 71.59 %(95%CI, 60.98% to 80.70%) ($p<0.001$).

DISCUSSION

To our knowledge, this work is the first to use a computational structure for predicting the prognosis of putting a patient on the conservative mode of treatment in case of cholecystitis. The advantage of the neural networks lies in their ability to recognize and process non-linear relationships. Given the clinical complexity, pathological heterogeneity, difference in experience and clinical acumen of attending clinicians, correct selection of treatment modality apriori is fraught with difficulties. Some previous studies have shown that clinicians are not aware of the complex clinical parameter inter-dependencies that a neural network can unravel. Two separate studies have compared accuracy of neural networks with that of clinicians to predict disease or outcome. In the first study, based on clinical and ECG findings, 8 out of 36 cases of MI were missed by physicians, compared with only 1 case missed by neural network yielding a sensitivities of 77.7%(95%CI, 77to 82.90%) and 97.2%(95%CI, 97.2 to 97.5%), respectively.[4] In another study, the accuracy of physicians to predict the outcome for colorectal cancer ranged from 75%(95%CI, 66 to 84%) to 79%(95%CI, 71 to 87%) compared with 90%(95%CI, 84 t0 96%) for the neural network.[8] It is pertinent to mention that these results may not be applicable to settings where the epidemiology of cholecystitis, substantially from the setting where this study was conducted.

Our study emphasizes several implications, regarding the medical applications of artificial neural networks as prognostic tools for conservative treatment of cholecystitis. The use of neural networks could provide healthcare professionals with a simple and efficient tool with which they can assess the failure/success of the conservative mode of treatment in cholecystitis.

What this study adds:

1. What is known about this subject?

The selection of treatment regimen for acute cholecystitis is purely dependent and directed by the experience, knowledge and clinical acumen of the attending clinician. Given the variability and diversity in these parameters of clinicians, the outcome also varies.

2. What new information is offered in this study?

This study demonstrates the hidden pattern finding power of pervasive computing in general and artificial neural networks in particular. This study outlines the applicability of artificial neural networks in treatment modality selection in acute cholecystitis and advocates the use of such computational structures in clinical decision-making. It is pertinent to mention that such structures cannot replace clinicians but could act as valuable tools in clinical decision-making.

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ETHICS COMMITTEE APPROVAL Approved

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