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COMPUTER-ASSSITED TRIAGE OF ABDOMINAL PAIN IN CHILDHOOD: A SUGGESTED CLINICAL ALGORITHM

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INTRODUCTION

Abdominal pain is a common clinical emergency. The challenge at the triage of such patients is to differentiate those who may safely be discharged home from those that require urgent medical or surgical consultation. Notwithstanding the technological advances in diagnosis, the patient with abdominal pain is to a large extent reliant on the clinical expertise of the caregiver for specific management The process of reaching the final diagnosis may necessitate in-hospital observation. As abdominal pain is especially prevalent as an emergency in childhood, delay in diagnosis may result in anxiety to the child, the family and the medical staff. The more experienced the clinician in the assessment of children with abdominal pain the more rapid and the more reliable the management.

Evidence from both clinical and psychological studies [Fiorovanti *et al.,* 1988] indicates an obvious advantage in rapid triage[1] of patients with abdominal pain. The central difficulty of the triage is the choice of clinical symptoms and signs (attributes) that in combination contribute the most to the diagnosis and management of these children. A pertinent reduced set of attributes should assist the triage nurse and help the emergency room physician. Despite the large number of publications that review the management of acute appendicitis, there seems to be little information concerning validity of the clinical procedures in the triage of this condition. Most papers focus either on the physician's ability to estimate the probability of the disease using clinical data [Hallan *et al.,* 1997], or on the development of a scoring systems to aid in the diagnosis of this condition [Anatol and Holder, 1995]. Moreover, the attempts to develop a computer-based assistant rely heavily on the physician's ability to make accurate probabilistic evaluations [Todd *et al.,* 1994].

In this paper we discuss how the identification of a minimal set of clinical symptoms and signs, followed by the development of a *clinical algorithm* can facilitate the triage of the child with abdominal pain. We also present the results of a limited prospective evaluation of such an algorithm. The attendant goals of parental satisfaction, improved patient compliance and a reduction in overall cost of medical services may also be achieved.

METHODS AND APPROACH

A retrospective analysis of the emergency records of children seen at the Children's Hospital of Eastern Ontario in Ottawa, Ontario, Canada for the period 1997-1999, was conducted using a knowledge discovery methodology called Rough Sets analysis [Pawlak, 1991]. On the basis of the discharge diagnosis (i.e. *final diagnosis*), the patients were classified into two distinct categories: *surgical consult* and *resolution*. All patients in the *surgical consult* group had confirmed acute appendicitis at varying pathological stages, while the *resolution* group included patients where all symptoms and physical findings resolved spontaneously without specific medical or surgical treatment. The cases not specifically covered by the above groupings were classified as *NYD* (not yet determined) and were not included in the construction of the *clinical algorithm*. Universally acknowledged clinical symptoms and signs used to evaluate abdominal pain in the emergency room were recorded for each patient. They included:

[1] The term *triage* used throughout the paper refers to the initial assessment of the patient.

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Attribute	Description
Age	Number of years
Sex	Gender
AbdPainDur	Duration of pain
AbdPainSite	Location of pain
AbdPainType	Type of pain
Vomiting	Number of times vomiting occurred
Vombile	Bilious vomit
PrevVis	Previous visit to ER in last 48 hours
Temp	Fever
AbdTend	Site tenderness
AbdMass	RLQ mass
WBC	White blood cell count

Subsequently, they were analyzed in order to develop a reduced core set of triage attributes and to generate classification rules for that set. Chart analysis and a methodology used to derive a reduced set and to develop corresponding classification rules have been described in greater detail in [Michalowski *et al.,* 2000].

RESULTS

Subsequent analysis of the rules, supported by consultation with pediatric medical staff allowed for the creation of a *clinical algorithm* that describes rudimentary medical knowledge associated with the triage of most children with abdominal pain in the emergency room.

Following a format accepted by the medical profession, such an algorithm can be expressed as a system of conditional statements:

The triage may be *surgical consult* when one of the following occurs:

- A male patient experiences right lower quadrant abdominal pain and his white blood cell count is above 20000/mm^3;
- A male patient experiences right lower quadrant abdominal pain lasting between 4h and 24h, combined with frequent vomiting;
- A male patient who already visited the ER in last 24 hours experiences right lower quadrant abdominal pain, combined with frequent vomiting;
- A patient experiences right lower quadrant abdominal pain combined with frequent vomiting and his/her white blood cell count is above 20000/mm^3;
- A patient experiences right lower quadrant abdominal pain combined with a fever of 37C - 39C and his/her white blood cell count is above 20000/mm^3.

The triage may be *resolution* when one of the following occurs:

- A patient experiences abdominal pain (neither right lower quadrant nor suprapubic) lasting between 4h and 24h;
- A patient experiences abdominal pain (neither right lower quadrant nor suprapubic) of intermittent character;
- A patient experiences abdominal pain (neither right lower quadrant nor suprapubic) not accompanied by vomiting;
- A patient experiences abdominal pain (neither right lower quadrant nor suprapubic) combined with a normal temperature and his/her white blood cell count is between 10000/mm^3 and 20000/mm^3;
- A patient experiences non-localized pain of intermittent character, combined with a normal temperature and his/her white blood cell count is between 10000/mm^3 and 20000/mm^3.

The above algorithm was further evaluated in a prospective study in order to determine its robustness and specificity. The testing cohort did not include the patients' charts that were used in the development of the *clinical algorithm*. Testing was conducted in the emergency room of the Children's Hospital of Eastern Ontario using 243 patients' files collected in summer 2000. The results of these tests are very promising. The algorithm suggested appropriate triage (as later confirmed by a discharge diagnosis) in about 70% of cases. Moreover, what is very important in medical decision-making, the *clinical algorithm* did not wrongly triage a single appendicitis patient into the *resolution* category. All errors resulted in advising a *surgical consult* for children where *resolution* was the final diagnosis (approx. 18% of the cases). Thirty per cent of cases were unable to be categorized into surgical consult or resolution. These constitute the NYD category. The above results were better than the initial emergency room diagnosis, which differed from the discharge diagnosis in more than one out of every three cases.

Discussions with medical staff concerning the use of the *clinical algorithm* in the emergency department suggested that the already reduced set of clinical attributes and signs should be further contracted so it can be effectively used by the triage nurse practitioner. Preliminary recommendations are that such a set should only include information on location of pain, type of pain and the WBC (all three already being part of the *clinical algorithm*). Clearly, one can expect that the accuracy of the algorithm may decrease. However its specificity may improve with the inclusion of the *NYD* category.

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DISCUSSION

Recent advances in the radiological diagnosis (including ultrasonography and computerized tomography) of the child with abdominal pain have improved the management. However, there is a "price" to be paid for the application of these diagnostic techniques in terms of cost, availability of experienced ultrasonographers, and increased time required for diagnosis. Ultimately, these procedures may contribute to improved medical diagnosis, but it is unlikely that they will have a significant impact on the child's triage, as by definition it requires only a brief clinical assessment of the child.

This paper looks at a minimal set of clinical symptoms and signs including a white blood count that can be helpful in the triage of the patient. The resultant *clinical algorithm* described in the paper reflects the inductive reasoning of an expert physician when diagnosing a patient with abdominal pain. It is intended for the use by a nurse practitioner. It asks primarily for the evaluation of basic clinical attributes. Thus, it requires information that can be assessed by an experienced nurse practitioner at the early stages of the child's management. The suggested course of action produced by the algorithm should be treated in the same fashion as the results of commonly accepted diagnostic tools such as X-rays etc., with an additional advantage that the algorithm provides instantaneously advice regarding patient's triage. Resultant immediate clinical action by the physician may result in earlier final diagnosis

The promising results reported here indicate the usefulness of our approach. The sensitivity of the *clinical algorithm* may be less than that of ultrasonography or computer tomography; but the ease of application and the potential economic saving are indisputable. At this point we are working on further refinement of the *clinical algorithm* and its computer implementation for the PDA device running Windows CE operating system. Such an easy to use set-up will undergo clinical evaluation in the hospital's emergency room and in local health centers. We believe that prospective evaluations will indicate that with the appropriate approach, basic and easily available clinical data might be effectively used in triage without resorting to expensive investigative procedures.

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Biography

Steven Rubin is a professor of surgery in the Faculty of Medicine at the University of Ottawa and Chief of the Division of General Surgery at the Children's Hospital of Eastern Ontario in Ottawa, Canada. As program Director of Pediatric Surgery, he is involved in medical teaching at the undergraduate and postgraduate levels. His research interests are predominantly in medical diagnostic methods.

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Roman Slowinski is a professor of operations research and head of the Laboratory of Intelligent Decision Support Systems at the Poznan Technical University, Poland. He is holder of European Chair at the University of Paris Dauphine and invited professor at the Swiss Federal Institute of Technology in Lausanne. He is also editor of the *European Journal of Operational Research*. His research interests include methodology and techniques of decision support, medical decision support, and rough sets theory among others. He has published 11 monographs, 3 textbooks and over 200 refereed papers.

Szymon Wilk is a doctoral student at the Poznan Technical Universty. His main research interests include machine learning, knowledge discovery and decision support systems.