Clinical diagnosis of acute bacterial rhinosinusitis, typical of experts

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Abstract

Background Clinical diagnosis of acute bacterial sinusitis (ABS) is a concern when a patient presents with nasal discharge of recent onset together with facial pain or pressure. Given this presentation, the doctor would benefit from having access to software that specifies, first, what diagnostic indicators experts typically use in that diagnosis and then, upon entry of those facts, what experts' typical probability of ABS is in such a case.

Methods We specified a set of 23 hypothetical presentations of this type by patients 20–75 years of age, involving a comprehensive set of clinical-diagnostic indicators. Members of an international expert panel independently set the probability of ABS in each of these cases. A logistic function of the diagnostic indicators was fitted to the medians of the probabilities.

Results The fitting led to an expression of the experts' median probability of ABS as a joint function of the duration of the patient's facial pain/pressure, and indicators of the location(s) of this; indicators of exacerbation of the pain/pressure on bending forward, nasal obstruction, maxillary and/or frontal tenderness, pus from middle meatus, purulent postnasal drip, and fever; and indicators of recent upper respiratory tract infection, nasal polyposis and status post sinus surgery. This probability function is accessible at http://www.evimed.ch/ABS.

Interpretation That probability function, made readily accessible, provides for expertly probability setting in clinical diagnosis of ABS, relevant for decisions about further diagnostics or treatment without further tests.

Introduction

When a patient presents with nasal discharge of recent onset together with facial pain or pressure, at issue is a case of acute rhinosinusitis. Infection of the paranasal sinuses, a common health problem, generally is of either viral or bacterial origin. The distinction between viral and bacterial infections bears on what treatment is recommended to the patient. Antibiotic therapy is of no benefit for patients with viral infection, while it reduces the duration of symptoms of acute bacterial rhinosinusitis [1,2].

The differentiation between viral and bacterial infection in acute rhinosinusitis is intricate. Radiography and computed tomography cannot be used to differentiate viral from bacterial sinusitis [3]. Sinus puncture or endoscopically collected secretions with culture of the aspirate is the most reliable test to differentiate between viral and bacterial rhinosinusitis [4–6]. This, however, is commonly not performed in a primary care setting. Thus, the diagnosis of acute bacterial sinusitis (ABS) commonly needs to be pursued on the basis of only history and physical examination [5,7]. The set of thus-derived, clinical facts on the patient generally is incompletely discriminating between the presence and absence of acute bacterial rhinosinusitis so that clinical diagnosis can represent only probabilistic knowing about its presence/absence.

While the correct clinical diagnosis/probability – of the presence of ABS – the probability that is warranted by the clinical-diagnostic profile – generally remains unknown, and while even experts' subjective diagnoses are quite divergent (in their probabilities), any doctor pursuing clinical diagnosis of ABS would do

Table 1 Statistical variates for comprehensive description of the clinical-diagnostic profile. Asterisk denotes indicator variate (1 if feature at issue is present, 0 if absent)

Variate	Specification†	Variate	Specification†
1	Age (years)	12	Fever*
2	Duration of nasal discharge (days)	13	Maxillary tenderness*
3	Duration of facial pain/pressure (days)	14	Frontal tenderness*
4	Maxillary pain/pressure*	15	Inner canthus tenderness*
5	Frontal pain/pressure*	16	Infraorbital tenderness*
6	Inner canthus pain/pressure*	17	Pus from middle meatus**
7	Exacerbation of pain bending forward*	18	Purulent postnasal drip*
8	Nasal obstruction*	19	Antecedent upper respiratory tract infection*
9	Type of nasal discharge‡	20	Propensity for bouts of allergic rhinitis*
10	Worsening after intermittent improvement*	21	Nasal polyposis*
11	Hyposmia	22	Status post sinus surgery*

†At most one of X_4 to X_6, and of X_{13} to X_{16}, indicates presence of the symptom (pain/pressure or tenderness respectively) in the hypothetical cases (cf. Appendix 1).

‡0 if serous, 1 if mucopurulent, 2 if purulent.

well substituting typical expert diagnosis for what otherwise would be prone to be an excessively subjective diagnosis/probability.

We studied how experts' typical diagnosis of ABS – the probability characterizing this – now is a joint function of (a subset of) the full set of clinical-diagnostic indicators that reasonably could be considered; and we made diagnosis based on this function accessible to doctors at large via their personal computers.

Methods

In studying experts' typical diagnosis of ABS (the probability of this) as a function of clinically available diagnostic indicators, we used the approach of Miettinen *et al.* [8] in addressing the experts' typical diagnosis of pneumonia.

For the pursuit of diagnosis of ABS we took the prompting complaint to be that of recent onset of nasal discharge together with facial pain or pressure, both still present, and this presentation we considered specifically in respect to persons 20–75 years of age.

The development of the questionnaire that a software system on this prompting would present to the diagnostician began with the two senior otorhinolaryngologists among us (DH and PO) independently, though in consultation with their respective local colleagues, coming up with their suggestions for the complete set of possible clinical-diagnostic indicators and their scales. Two others among us (OSM and JS) translated these into a first draft of the questionnaire, which the senior otorhinolaryngologists critically examined, again in consultation with their colleagues. A couple of iterations led to the questionnaire's final form. It implied 22 statistical variates for full description of the clinical-diagnostic profile of any given case. These variates are specified in Table 1.

The number of elements in any profile specified by filling out the questionnaire (22, Table 1) meant that scores of hypothetical profiles ideally would have been specified for expert diagnoses. Concerned to keep the number to the bare minimum necessary, we specified only 36 cases, all distinct. Three considerations governed the case specifications, though quite informally. One of these was the concern to cover all possible cases by the resulting clinical-probability function but with accent on low-probability cases, so as to serve particularly well the aim of providing for practical rule-out diagnoses (of ABS) without non-clinical testing. Another, competing one was maximization of the efficiency of learning, calling for maximal variability of any given one of the diagnostic indicators. The third consideration, also efficiency-oriented, was the concern to minimize collinearity among (the statistical variates representing) the different diagnostic indicators in the database, multiple collinearity included. The hypothetical cases that thus were specified are documented in Appendix 1, and an example of a narrative counterpart of these specifications is given in Appendix 2.

The narratives of the 36 hypothetical case profiles were presented to the members of an international panel with 23 respondents. The formation of this panel is documented in Appendix 3, which also specifies the responding members. The main task of each of the panel members was to set, independently in each of the 36 cases, the diagnostic probability for ABS, meaning: the (presumptive) proportion of instances of the profile in general such that ABS is present.

The case-specific medians of the expert probabilities were used to derive a logistic function for the clinical probability of ABS being present, applying a General Linear Model to the logits of those probabilities. The independent variates included, first, those specified in Table 1, with exclusion of two of them (see footnote in Table 1). We then explored the logit's quadratic relations to the quantitative indicators (age, duration of nasal discharge, duration of facial pain, and maximum temperature) and the potential need for product terms in the regression model.

Results

The medians and ranges of the responding experts' probabilities for ABS in each of the 36 hypothetical cases are presented in Table 2. The medians ranged from 10% to 80%, the widths of the ranges from 30 percentage points to 100 percentage points.

The regression analyses led to the probability function $P = 1/[1 + \exp(-S)]$ involving

$$S = -2.13 + 0.30X_4 + 0.24X_5 + 0.62X_7 + 0.51X_8 + 1.12X_9 + 0.38X_{10} + 0.92X_{12} + 0.22X_{13} + 3.12X_{17} + 2.44X_{18} + 0.88X_{19} + 0.23X_{21} - 0.70X_4 \times X_{17}.$$

Table 2 For each of the 36 hypothetical cases (Appendix 1), the median and range of the probabilities for acute bacterial sinusitis set by the international panel of experts

	Probability			Probability	
Case	Median	Range	Case	Median	Range
1	0.20	0.00–0.90	19	0.15	0.00–0.60
2	0.30	0.00–0.80	20	0.80	0.10–1.00
3	0.70	0.00–1.00	21	0.50	0.05–1.00
4	0.15	0.00–0.70	22	0.80	0.05–0.90
5	0.20	0.00–0.70	23	0.80	0.10–1.00
6	0.10	0.00–0.40	24	0.10	0.00–0.60
7	0.10	0.00–0.80	25	0.15	0.00–0.60
8	0.50	0.05–0.99	26	0.10	0.00–0.30
9	0.50	0.00–0.90	27	0.15	0.00–0.50
10	0.20	0.00–0.75	28	0.20	0.00–0.70
11	0.50	0.00–0.95	29	0.15	0.00–0.80
12	0.35	0.00–1.00	30	0.60	0.10–0.99
13	0.80	0.30–1.00	31	0.10	0.00–0.60
14	0.30	0.00–0.90	32	0.10	0.00–0.40
15	0.75	0.25–1.00	33	0.10	0.00–0.30
16	0.35	0.10–0.80	34	0.80	0.05–1.00
17	0.10	0.00–0.60	35	0.70	0.10–0.99
18	0.15	0.00–0.70	36	0.15	0.00–0.80

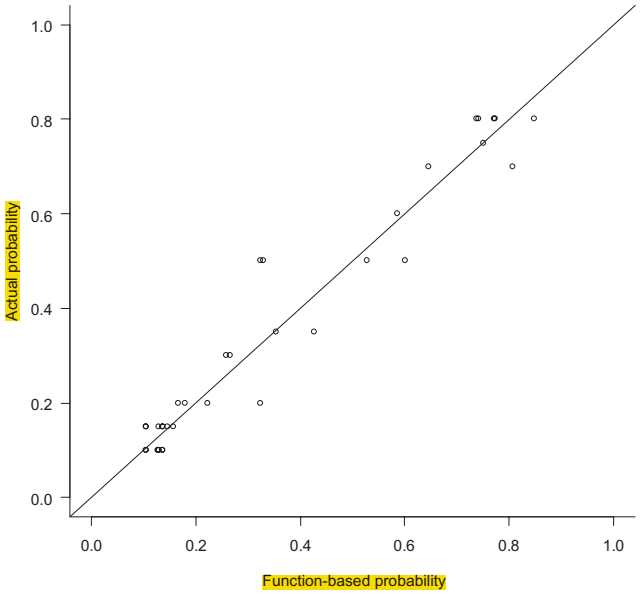

Figure 1 Goodness of fit of the international panel reduced probability function. The 'actual probabilities' are the medians from the international expert panel (Table 2). The line corresponds to identity of the two types of probability.

Each of the deleted variates, when added to those in this scoring function one at a time, changed the score value by ±0.20 at most.

The goodness of fit of this probability function is addressed in Fig. 1, indicating how well this function characterizes the typical (median) expert diagnoses in the 36 hypothetical cases. For the actual case-specific medians' deviations from the model-implied values, the median is 0 and the range is from –0.12 to 0.18. The regression coefficient is 0.99.

Discussion

Acute rhinosinusitis is one of the most common reasons for consulting a primary care doctor, and its presumedly bacterial form is one of the most common reasons for the doctor to prescribe antibiotics [9,10]. The diagnosis of acute rhinosinusitis and the differentiation between bacterial and viral rhinosinusitis is usually based on clinical findings – from history and physical examination – alone; and the correct probability for the presence of acute purulent rhinosinusitis, ABS, given the clinical profile of the case, is generally unclear.

Lindbaek and Hjortdahl [4] performed a systematic review of studies concerning clinical diagnosis of 'acute purulent sinusitis' (APS). Four studies [11–14], each of them performed in a general practice setting, fulfilled the inclusion criteria. The set of diagnostic indicators identified by logistic regression analysis as being helpful in diagnosing APS varied among the studies. Purulent secretion and pain in the maxillary region were associated with APS in two of the four studies. But insofar as 'purulent' is taken to denote the bacterial form of sinusitis, only the study by Hansen [11] should have been included in the review, as the other studies did not involve sinus puncture as the reference test and radiography is not an appropriate basis for differentiating between the bacterial and viral forms of sinusitis. In that study with a reliable reference test, neither purulent secretion nor purulent rhinorrhoea, or unilateral maxillary pain were associated with APS; only increased blood sedimentation rate (>10 mm) was.

Two studies, one published by Berg and Carenfelt [15] and the other by Axelsson and Runze [16], were excluded in that review on the basis that they had been performed in ear, nose and throat practices, taking this to mean of limited relevance to general practice. Berg applied sinus puncture and visual examination of the aspirate as the reference test, and he identified four symptoms and signs as being associated with APS: 'history of purulent nasal discharge with unilateral predominance, history of bilateral purulent nasal discharge, history of pain with unilateral predominance, and pus in the nasal cavity on physical examination'. If three or four of the 'parameters yielded a positive result, the sensitivity was 81% and the specificity 88%'. Axelsson used sinus X-ray as the reference test and found 'purulent rhinorrhoea, preceding upper respiratory infection, cough, hyposmia, and malaise to be associated with APS'.

Engels *et al.* [17] performed a systematic review of studies on diagnostic laboratory tests for acute sinusitis and deemed many of them to be of 'poor quality, with inadequately described methods'; and he called for the development of diagnostic trials to improve the care of patients with acute sinusitis.

Symptoms and physical signs, when viewed in isolation, are only moderately useful in the diagnosis of ABS, in setting the probability for the presence of ABS. To our knowledge, no published study has heretofore addressed the probability of ABS as it depends on symptoms and physical signs, considered jointly in a multivariable model.

Among the experts contributing to this study there was a remarkable variability in the case-specific diagnostic probabilities,

even if unsurprisingly [18–21]. It underscores the importance of having, in the development of the knowledge base of expertly diagnosis and it implies that, in the context of a given diagnostic profile, the proper question for a non-expert to consider is not, what an expert's diagnosis – diagnostic probability – regarding a particular illness would be; the proper question is about a typical expert's diagnosis.

Nasal discharge of recent onset together with facial pain or pressure is a frequent reason to consult a physician. Acute sinusitis is suspected on symptoms and signs, but only in few patients is ABS reliably ruled in or out. Despite the uncertainties in the diagnosis of acute sinusitis and in the differentiation between the bacterial and viral forms of it, physicians prescribe antibiotics to most [4], or nearly all [22,23], of these patients. So long as no results of scientific pendants of our quasi-scientific study are available, the prevalence function we derived should be helpful in setting the probability of ABS, thereby leading to a reduction in unnecessary prescriptions for antibiotics at least to patients with a low calculated probability of ABS.

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Appendix 1

Clinical-diagnostic profiles in 36 hypothetical cases, in terms of the statistical variates defined in Table 1

Case	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	x_{19}	x_{20}	x_{21}	x_{22}
1	75	7	5	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
2	50	15	5	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
3	75	10	5	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
4	50	10	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
5	50	7	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
6	20	20	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	20	15	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	50	15	10	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
9	20	4	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
10	50	7	5	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
11	20	12	10	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0
12	75	12	2	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
13	50	12	2	0	0	1	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	0
14	75	12	10	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
15	75	15	5	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
16	20	10	5	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0
17	20	15	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	50	4	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19	75	7	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
20	20	7	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
21	20	7	5	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1
22	50	12	10	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
23	20	4	2	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0
24	75	4	2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
25	75	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
26	50	12	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	75	20	10	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
28	20	15	10	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
29	20	15	5	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
30	75	20	10	0	1	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0
31	20	12	2	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
32	75	7	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
33	50	10	5	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
34	75	12	10	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
35	50	12	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
36	50	20	10	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Appendix 2

Narratives

The narratives of the hypothetical cases (App. 1) presented to the expert panels are exemplified by one case:

Case 1

75 years old, with nasal discharge since **7** days and facial pain since **5** days, without immediately antecedent dental pain.

More on history

Location of pain:

maxillary – **yes**
frontal – **no**
inner canthus – **no**

Exacerbation of pain on bending forward – **no**
Nasal obstruction – **no**
Nasal discharge – **serous**
Worsening of symptoms after intermittent improvement of symptoms – **no**
Hyposmia – **no**
Maximal measured body temperature – **36.8**°C

Physical examination

Tenderness (pain on palpation):

maxillary – **yes**
frontal – **no**
inner canthus – **no**
infraorbital **–no**

Pus from middle meatus – **no**
Purulent postnasal drip – **no**

Risk indicators
Immediately antecedent upper respiratory tract infection – **yes**
Propensity for bouts of allergic rhinitis – **no**
Nasal polyposis – **no**
Status post sinus surgery – **no**

Appendix 3

The International panel

J. Steurer approached Dr. D. Holzmann, Head of Division of Rhinology, Department of Otorhinolaryngology and Head and Neck Surgery, University of Zurich, on our concern to have an international panel of experts on clinical diagnosis of ABS. The latter approached Dr. G. Rettinger, President of the European Rhinologic Society, and Dr. H. Stammberger, a founding member of the European Academy of Otorhinolaryngology, Head and Neck Surgery and a representative for Austria, Germany and Switzerland in the European Federation of ORL-Societies. These two specified 72 top experts. J. Steurer wrote to each of these, attaching documents explaining what the project was about and attaching also the file of the 36 narratives of hypothetical case profiles together with the response form. In the response form the panel member was to give his best understanding of the percentage of cases of the specified type (case #1, etc.) such that the patient has acute purulent rhinsosinusitis.

Of the 72 nominees from Europe 23, responded with what was requested. These colleagues were: Dr. C. Bernal-Sprekelsen, Dr. J. Bretschneider, Dr. M. Caversaccio, Dr. H. Doble, Dr. J. Hadley, Dr. S. Heimberg, Dr. J. Hof, Dr. K. Hörmann, Dr. P. Hellings, Dr. L. Jure, Dr. V. Lund, Dr. J. Maurer, Dr. D. Miličić, Dr. R. Mladina, Dr. R. Prsatačić, Dr. D. Passali, Dr. C. Rudack, Dr. B. Senior, Dr. S. Steinsvag, Dr. P. Stierna, Dr. B. Stuck, Dr. T. Tami, and Dr. A. Wun.