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ORIGINAL ARTICLE

Diagnostic probability function for acute coronary heart disease garnered from experts' tacit knowledge

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Abstract

Objectives: Knowing about a diagnostic probability requires general knowledge about the way in which the probability depends on the diagnostic indicators involved in the specification of the case at issue. Diagnostic probability functions (DPFs) are generally unavailable at present. Our objective was to illustrate how diagnostic experts' case-specific tacit knowledge about diagnostic probabilities could be garnered in the form of DPFs.

Study Design and Setting: Focusing on diagnosis of acute coronary heart disease (ACHD), we presented doctors with extensive experience in hospitals' emergency departments a set of hypothetical cases specified in terms of an inclusive set of diagnostic indicators. We translated the medians of these experts' case-specific probabilities into a logistic DPF for ACHD.

Results: The principal result was the experts' typical diagnostic probability for ACHD as a joint function of the set of diagnostic indicators. A related result of note was the finding that the experts' probabilities in any given case had a surprising degree of variability.

Conclusion: Garnering diagnostic experts' case-specific tacit knowledge about diagnostic probabilities in the form of DPFs is feasible to accomplish. Thus, once the methodology of this type of work has been ''perfected,'' practice-guiding diagnostic expert systems can be developed. © 2013 Elsevier Inc. All rights reserved.

Keywords: Chest pain; Diagnosis; Acute coronary heart disease; Diagnostic probability function; Tacit knowledge; Experts

1. Introduction

Diagnosis can be thought of as knowing about the presence/absence of a particular illness in a patient at a particular time. That knowing can only be probabilistic whenever the available facts on the case do not fully determine the nature of the underlying illness. Thus, the diagnostic challenge is to know about the probability that the illness in question is actually present, that is, about the proportion of instances at the set of facts—the diagnostic profile—in general such that the illness is present.

Despite the central role of diagnosis in medicine, the requisite knowledge base for setting diagnostic probabilities remains practically nonexistent for today's medicine. For example, textbooks of cardiology give no diagnostic probabilities for myocardial infarction specific to particular clinical profiles of the case, nor are these probabilities codified anywhere else.

This is not altogether surprising, given how challenging the form of the requisite knowledge base and the development of knowledge of that form are. Given a patient from a particular demographic category (e.g., an adult male) with a particular chief complaint (e.g., chest pain), the relevant further particulars (e.g., age, type of pain, location of pain, history of coronary heart disease …) of the case imply an enormous number of possible diagnostic profiles in the context of the presentation at issue. The development and codification of knowledge about the diagnostic probability separately for each of the multitude of possible diagnostic profiles is unrealistic as a goal.

Thus, the need is to address diagnostic probability as a joint function of the diagnostic indicators involved, but research directed to such functions, in turn, commonly involves major challenges, especially from the need to

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What is new?

This project produced a diagnostic probability function for acute coronary heart disease on the basis of experts' tacit, case-specific knowledge about these probabilities; and it also shows great inter-expert variability in those probabilities. Both of these results are unprecedented. Production of such DPFs was shown to be feasible but in need for further methodologic development; and even more important turns out to be development of greater expertise among emergency-rooms doctors in the diagnosis about ACHD.

determine, for each of the study subjects, the truth about the presence/absence of the illness in question.

These major challenges in the development of the requisite knowledge base for diagnosis raise the question of whether it would be feasible to garner the tacit knowledge about diagnostic probabilities possessed by diagnostic experts in the requisite form of diagnostic probability functions (DPFs). The work reported here represents our attempt at answering this question, focusing on the diagnosis of acute coronary heart disease (ACHD; i.e., unstable angina pectoris or myocardial infarction) in the context of chest pain and/or dyspnea as the chief complaint of an adult.

2. Methods

Focusing on diagnosis of ACHD, we took the prompting complaint to be that of acute chest pain and/or dyspnea in a person at least 18 years of age. The main components in developing the function for experts' typical probability of ACHD in that domain were the development of a questionnaire with a view to specification of the diagnostic profile of any given case, specification of a set of hypothetical cases in terms of filled-out versions of this questionnaire, formation of a panel of experts on the diagnosis and having them set the diagnostic probability for each of the cases, and translation of these probabilities into the DPF.

2.1. Development of the questionnaire

In the development of the questionnaire, the initial step was a review of all published ''prediction rules'' for ACHD diagnosis [1] as the basis for the formation of a first draft of a comprehensive set of the diagnostic indicators to consider. We included all these in the first draft of the questionnaire. We consulted senior internists and cardiologists in Zurich about this draft questionnaire, asking for their suggestions for further diagnostic indicators and the scales of these. This led to the next draft of the questionnaire, which the senior internists/cardiologists again critically examined. Two further iterations led to the questionnaire's final form given in Appendix A.

2.2. Specification of hypothetical cases

Based on the questionnaire and concerned to keep the number to a bare minimum necessary for a demonstration project, we specified 80 hypothetical cases, all different.

Two considerations governed the case specifications. One of these was the concern to minimize the number of cases with ST changes or elevated cardiac enzymes, so as to enhance the discernment of the relevance of less-discriminating diagnostic indicators. The other consideration was the concern to minimize the correlatedness of the diagnostic indicators in the database.

2.3. Garnering experts' diagnoses

We contacted 24 directors of departments of internal medicine in 3 university hospitals and 21 affiliated teaching hospitals in Switzerland, asking them to nominate from their hospital one or two physicians with a high degree of diagnostic expertise on cases of acute chest pain and/or acute dyspnea. Of the 24 directors, 23 nominated one or two experts, for a total of 37. All 37 agreed to serve on the panel, but actually, only 32 of them addressed all the cases presented to them. These 32 experts are specified in Appendix B.

We divided the 80 cases into five subsets of 16 cases each. Each expert received four of these five subsets, in a random order, with the cases within the subsets also randomly ordered. The subsets were submitted sequentially, the second through fourth submission some time after the work on the previous subset.

The case specifications were available online on the Internet, accessible only with a personalized password. The task of the panel members was to set, independently of the other members of the panel, the diagnostic probability for ACHD for each of the 64 hypothetical cases. They were instructed to think, after reading the case description, about 100 cases like the one described in the vignette and estimate how many of them are cases of ''acute coronary syndrome (unstable angina pectoris or myocardial infarction).'' The experts' probability estimates were stored in the project's database, accessible only to the principal investigator.

For the development of the DPF, we excluded data from some of the 32 members of the panel, based on two considerations. We first examined the distribution of the expert-specific means of the 64 probabilities associated with the cases they addressed. The highest mean was 74%, followed by 53%, and the lowest mean was 21%, followed by 23%. On this basis, we excluded the data from the panel member with the highest mean. The second consideration was the pattern of variation of the expert-specific probabilities. On this basis, we excluded from the remaining 31 sets of probabilities those with a coefficient of correlation of less than 0.50 with the means of the others. Five sets of probabilities

Table 1. For each of the 80 hypothetical cases, the median, IQR (Q25–Q75), and total range of the probabilities for ACHD set by the 26 experts

Case	Median	IQR	Range	Case	Median	IQR	Range
1	10	5–15	2–60	41	30	18–66	10–86
2	10	6–28	5–81	42	15	10–55	5–70
3	21	10–30	5–70	43	27	15–50	5–73
4	27	20–50	2–70	44	25	10–32	3–85
5	30	21–50	5–80	45	20	10–40	4–90
6	31	20–50	15–80	46	15	9–30	4–77
7	60	30–70	5–80	47	30	23–72	5–85
8	53	30–80	15–93	48	7	5–15	2–85
9	75	50–85	16–90	49	5	3–10	1–20
10	30	25–80	5–90	50	60	40–80	5–98
11	20	10–50	5–80	51	11	5–30	0–85
12	10	7–15	2–60	52	45	25–75	9–90
13	25	10–51	5–77	53	15	8–30	1–80
14	40	15–60	5–96	54	11	5–30	0–73
15	20	10–30	5–83	55	6	5–10	0–46
16	16	10–40	5–71	56	20	10–32	3–60
17	33	20–63	5–90	57	73	25–90	10–100
18	38	18–62	4–90	58	50	25–75	10–93
19	21	10–77	0–100	59	28	10–50	4–84
20	57	37–78	5–85	60	60	40–75	10–99
21	10	7–18	1–51	61	67	45–80	15–98
22	28	18–51	0–90	62	33	20–50	2–80
23	78	63–90	25–100	63	8	5–19	0–70
24	17	8–33	0–80	64	21	8–42	1–70
25	10	5–21	0–70	65	56	38–85	0–96
26	50	20–78	5–100	66	20	6–25	3–80
27	58	25–83	1–95	67	20	10–30	2–50
28	44	31–87	10–100	68	35	13–57	1–90
29	18	14–32	5–50	69	20	5–36	1–85
30	24	9–50	2–85	70	70	45–82	5–99
31	69	43–83	7–95	71	10	4–18	0–40
32	15	10–30.0	5–69	72	10	5–15	1–50
33	50	20–71.0	10–83	73	71	35–85	5–99
34	9	5–15.0	2–36	74	60	40–70	10–95
35	15	5–32.0	3–75	75	46	40–60	9–90
36	10	2–10.0	0–24	76	20	5–30	0–70
37	5	1–5.0	0–14	77	50	16–71	1–100
38	20	10–45.0	1–70	78	30	15–50	2–75
39	30	10–74.0	0–95	79	37	15–50	5–90
40	66	30–90.0	10–93	80	70	40–90	20–100

Abbreviations: IQR, interquartile range; ACHD, acute coronary heart disease.

were excluded on this basis. This left us with 26 expert-specific sets of probabilities (for 64 of the 80 cases), with mean probabilities (across the 64 cases) ranging from 21% to 53% across the 26 experts.

2.4. Development of the DPFs

The case-specific medians of the probabilities from the 26 experts were used to develop a logistic probability function for ACHD, applying a general linear model to the logit of that median probability. The independent variates in the model, 54 in number, are specified in Table 2.

As the number of independent variates was quite large as a proportion of the number of vignettes (54 of 80), the result of the model's fitting required "shrinkage." We performed this by means of the James–Stein method [2].

3. Results

The experts' case-specific probabilities of ACHD are addressed in Table 1 in terms of giving for each of the 80 cases the experts' probabilities in terms of their median, first and third quartiles, and range. Across the 80 cases, the experts' median probabilities ranged from 5.0% to 77.5%, their case-specific interquartile range had values from 4.0 to 66.5 percentage points, and the case-specific range had values from 14 to 100 percentage points.

Table 2 specifies the statistical variates in the model and gives the fitted values for the parameters in it, together with the standard errors of the latter. The counterpart of this with the shrinkage has an intercept of 2.31, and the coefficients of X_1 through X_{54} are those in Table 2 multiplied by 0.87.

The probability functions without and with the shrinkage give probabilities ranging from 5% to 82% and 6% to 76%, respectively, when applied to the 80 hypothetical cases. Among cases different from those, the result can be less than 2% even when applying the result with the shrinkage.

4. Discussion

In the work described here, the focus was on a preeminent diagnostic challenge in medicine, namely the diagnosis of the presence/absence of ACHD. This diagnosis is an outstanding challenge because of not only its commonality but also the air of emergency that surrounds it. In this study, an added feature of note is the presumptive existence of experience-based expertise to which the rapid emergence of truth about the presence/absence of ACHD also importantly contributes.

Given these features of the particular topic here and the care with which the panel members were recruited, it was surprising and disappointing for us to find the high degree of divergence among the case-specific probabilities among the members of the expert panel (Table 1). This may cast doubt into thinking about the usefulness of DPFs expressing experts' typical probabilities, especially when the presumptive degree of attainable expertise is less than in the example addressed here.

The variability of the diagnostic probabilities among experts has implications even for the experts themselves, not only within but also outside the panel in a project of this kind. Any given expert needs to appreciate that a second opinion from an expert colleague could be at considerable variance with the probability characterizing the initial diagnosis. It thus should be a concern of the experts to know what other experts' diagnostic probability typically would be in any given case encountered. And, nonexperts should be even more concerned to know experts' typical

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Table 2. Result of fitting the model, involving X_1 through X_{54}, to the 26 sets of data on 80 hypothetical cases. With the shrinkage, the intercept (2.79) is replaced by 2.31, and the coefficients of X_1 through X_{54} are multiplied by 0.87

Variate	Definition of the variate	Coefficient	SE
X_0		2.79	5.28
X_1	Log of time, in hours, since onset of symptoms	−0.12	0.39
X_2	$(X_1)^2$	−0.0016	0.17
X_3	Log of duration of symptoms in minutes	0.85	0.93
X_4	$(X_3)^2$	−0.10	0.13
X_5	Indicator of dyspnea	0.49	0.24
X_6	Indicator of chest pain	0.98	0.33
X_7	Indicator of burning type of chest pain	−0.24	0.48
X_8	Indicator of pressure/tightness type of chest pain	0.12	0.37
X_9	Indicator of aggravation of chest pain by inspiration or change of position	−0.15	0.42
X_{10}	Indicator of radiation of chest pain	0.39	0.28
X_{11}	Indicator of nausea during episode	0.27	0.21
X_{12}	Indicator of diaphoresis during episode	0.32	0.21
X_{13}	Indicator of dizziness during episode	0.19	0.20
X_{14}	Indicator of fever just before episode	−0.73	0.21
X_{15}	Indicator of leg pain just before episode	−0.47	0.29
X_{16}	Indicator of angina before present chest pain	−0.19	0.25
X_{17}	Indicator of prior angina provoked by lesser exertion and/or lasting longer	0.68	0.32
X_{18}	Indicator of palpitations in days before episode	0.14	0.22
X_{19}	Smoking, number of cigarettes per day, in month before episode	−0.050	0.054
X_{20}	$(X_{19})^2$	0.0023	0.0027
X_{21}	Indicator of respiratory infection during prior 2 weeks	−0.20	0.29
X_{22}	Indicator of physical exertion immediately before episode	0.18	0.20
X_{23}	Indicator of emotional stress immediately before episode	0.028	0.22
X_{24}	Indicator of cocaine use immediately before episode	0.55	0.50
X_{25}	Age in years	−0.033	0.069
X_{26}	$(X_{25})^2$	0.00030	0.00054
X_{27}	Indicator of male gender	0.18	0.23
X_{28}	Body mass index in kg/m^2	−0.41	0.41
X_{29}	$(X_{28})^2$	0.0082	0.0079
X_{30}	Smoking, number of pack years	0.019	0.013
X_{31}	$(X_{30} - 10)^2$	−0.0031	0.0026
X_{32}	Indicator of doctor recommendation for antihypertensive treatment	0.0029	0.18
X_{33}	Indicator of doctor recommendation for lipid-lowering treatment	−0.020	0.18
X_{34}	Indicator of doctor diagnosis of diabetes	0.37	0.22
X_{35}	Indicator of doctor diagnosis of peripheral vascular disease	0.26	0.19
X_{36}	Indicator of doctor diagnosis of stroke	0.062	0.21
X_{37}	Indicator of doctor diagnosis of myocardial infarction	1.00	0.26
X_{38}	Indicator of pale skin	0.27	0.16
X_{39}	Indicator of irregular pulse	−0.19	0.21
X_{40}	Heart rate in beats per minute	−0.021	0.043
X_{41}	$(X_{40})^2$	0.00014	0.00024
X_{42}	Mean blood pressure	−0.0072	0.0067
X_{43}	Indicator of heart failure at physical examination	0.44	0.32
X_{44}	Indicator of pericardial rub at physical examination	−1.36	0.47
X_{45}	Indicator of chest pain aggravated by pressure on chest at physical examination	0.10	0.31
X_{46}	Indicator of difference in leg circumference at physical examination	−0.04	0.34
X_{47}	ST elevation/depression in millivolts	−0.42	1.03
X_{48}	$(X_{47})^2$	0.77	0.49
X_{49}	Indicator of hyperacute T	1.47	0.41
X_{50}	Indicator of arrhythmia, left bundle branch block, and/or T inversion	0.24	0.20
X_{51}	Indicator of elevated myoglobin	1.02	0.38
X_{52}	Indicator of elevated troponin	2.29	0.41
X_{53}	$X_1 \times X_{47}$	0.46	1.48
X_{54}	$X_2 \times X_{47}$	−0.35	0.62

Abbreviation: SE, standard error.

probability for the illness in question in any given case they are confronted with.

The function developed in this project is useful so far as it validly produces diagnostic probabilities extreme enough for action conditional on presumptive presence or absence of the illness, ACHD. Although the case-specific median probabilities ranged from 5.0% to 77.5%, the values produced even by the function with shrinkage have a larger

range, from less than 1% to more than 95% depending on the realizations of the Xs. It thus is evident that probabilities extreme enough for action, whether for referral to coronary care unit or practical ruling out of ACHD, are provided by the function.

In the context of an adult presenting with the chief complaint of chest pain and/or dyspnea, an example of the other elements in the differential-diagnostic set is pulmonary embolism. This possibility was allowed for in the questionnaire in respect to physical examination of legs, but no consideration was given for indicators of risk specific for pulmonary embolism, such as recent protracted immobilization. In a work of this kind in general, attention should be given to all the elements in the differential-diagnostic set implied by the presentation, and the risk-related and manifestational elements in the chosen set of diagnostic indicators should presumptively be discriminating among the elements in this set.

The need to attend to all the differential-diagnostic possibilities does not mean that the composition of the expert panel should reflect the set of disciplines of medicine that are principally concerned with each of the possible illnesses. Instead, the panel needs to be chosen as it was chosen in this project, on the basis of experience with the situation—the type of presentation—in which the differential-diagnostic challenge arises.

In the design of an inquiry along the lines of the present project, a topic apart from the content of the questionnaire is the way in which the content is presented to the members of the expert panel. Although we presented the information by filling out the questionnaire (Appendix A) for each of the hypothetical cases, we now think that a presentation more comfortable to the panel members and better for the solicitation of their actual insights would be biphasic. In the first part of the case specification presented would be the principal facts on the case, those on the principal diagnostic indicators identified on the basis of the experts' ranking of the indicators by informativeness. This part would then be supplemented by a part addressing the remainder of the elements in the diagnostic profile of the case. We recommend random ordering of the elements in each of the two sections, the randomization being separate for each of the members of the panel.

For DPFs meant to be applied in practice, a degree of precision greater than that in this demonstration project would be reasonable to pursue. This means, for one, the concern to have a larger number of experts to address each of hypothetical cases. Another concern, quite different in kind, has to do with the number of vignettes addressed by the panel of experts. The inherent informativeness of the diagnostic indicators is not fully manifest when needing to deploy a shrinkage factor, and on this basis the number of vignettes presented to the panel should be larger in proportion to the number of parameters in the model than it was in this demonstration project. Related to this is the question of optimization of method of shrinkage or of dealing with the problem in some other way. Finally, as for the efficiency of the development of these functions, a critical issue is the design of the vignettes in respect to their pattern of distribution by the diagnostic indicators involved. Technical topics of this nature will be addressed in a separate communication.

Although the art of producing DPFs from diagnostic experts' tacit knowledge thus remains somewhat incompletely developed, to say nothing about the developments' incomplete deployment in the present demonstration project, it is quite evident that DPFs descriptive of expert diagnoses are feasible to produce. These functions also are very inexpensive to produce relative to diagnostic research that does not draw from expertise but addresses diagnostic probabilities in the meaning of empirical frequencies of the illnesses in question being present. It therefore seems to us that work of this kind, after the requisite methodological developments, should indeed be entered into a large scale so that the knowledge base of diagnosis would get to be quite comprehensively codified in the form of DPFs.

Once the knowledge base of diagnoses has been comprehensible codified for any given discipline of medicine (e.g., general practice), these functions presumably would be the core of a discipline-specific diagnostic expert system. The diagnostician would approach the system by specifying the case presentation (e.g., chest pain as the chief complaint by an adult). In response to this, the system would specify what facts the diagnostician should ascertain from history, physical examination, and whatever other routinely available sources, such as electrocardiography. On having entered all this information into the system, the system would respond by laying out the complete differential-diagnostic set, and for each of the elements in this set, the system would specify the typical expert probability. At this point, the diagnostician would be able to express lack of satisfaction with the probabilities as for their failure to supply practical rule-in or rule-out probability for a particular illness among the possibilities, and the system would give expert advice on what testing therefore is called for. Having obtained the results of those tests, the diagnostician would enter them as additions to the diagnostic profile, and the system would consequently update the diagnostic probabilities. There could be one or more further cycles of such testing. This, we think, should be seen to be the essence of diagnostic professionalism in this Information Age.

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Appendix A

Questionnaire

Diagnosis of acute coronary syndrome: clinical and ECG inputs

Prompting of diagnostic pursuit: Patient (of either gender), 30 years of age or older, presents with the chief complaint of very recent − within 12 hours − episode of acute dyspnea and/or acute chest 'pain' (retrosternal) sustained at rest; that is, the patient presents with a possible case of unstable angina or myocardial infarction.

At issue is diagnosis on the patient's arrival (rather than upon updating of inputs).

A. The episode (in recent hours)

1. Particulars of the episode
   (a) Time since onset of symptom(s) (until arrival to emergency room): : ____ hours
   (b) Duration of symptom(s): ____ hours, ____ minutes
   (c) Type of symptom(s):
      (i) dyspnea: no ( ), yes ( )
      (ii) chest 'pain' (retrosternal): no ( ), yes ( ): if yes,
   (a) sharp pain ( ), burning ( ), pressure/tightness ( )
   (b) aggravated by inspiration or change of position: no ( ), yes ( )
   (c) radiating to left arm/shoulder and/or neck/chin: no ( ), yes ( )
2. Associated symptoms
   (a) During the episode
      (i) nausea: no ( ), yes ( )
      (ii) diaphoresis: no ( ), yes ( )
      (iii) dizziness: no ( ), yes ( )
   (b) Just prior to the episode
      (i) fever: no ( ), yes ( )
      (ii) leg pain: no ( ), yes ( )
3. In days prior to the episode (in A),
   (a) pre-existing angina pectoris provoked by lesser exertion and/or lasting longer: no ( ), yes ( ), no pre-existing angina pectoris ( )
   (b) palpitations (not pre-existing): no ( ), yes ( )

B. Possible prompters of the episode

1. During prior month, cigarette smoking: ____/day
2. During prior two weeks, upper respiratory infection: no ( ), yes ( )
3. Immediately prior,
   (a) unusual physical exertion: no ( ), yes ( )
   (b) unusual emotional stress: no ( ), yes ( )
   (c) cocaine use: no ( ), yes ( )

C. Background risk for AMI

1. Age: ____ yrs
2. Gender: female ( ), male ( )
3. Height: ____ cm
4. Weight: ____ kg (BMI: ____)
5. Cigarette smoking: no ( ), yes ( ): if yes, ___ /day (since age 15, ____ pack-years)
6. History (positive, prior to present episode) of
   (a) doctor recommendation for
      (i) antihypertensive treatment: no ( ), yes ( )
      (ii) lipid-lowering treatment: no ( ), yes ( )
   (b) doctor diagnosis of
      (i) diabetes: no ( ), yes ( )
      (ii) peripheral vascular disease: no ( ), yes ( )
      (iii) stroke: no ( ), yes ( )
      (iv) myocardial infarction: no ( ), yes ( )

D. Physical examination findings

1. Skin: pale and/or clammy: no ( ), yes ( )
2. Pulse: regular ( ), irregular ( )
3. Heart rate: ____/minute
4. Blood pressure: ____/____ mm Hg
5. Signs of heart failure (pulmonary rales, raised jugular pressure): no ( ), yes ( )
6. Pericardial rub or pleural rub: no ( ), yes ( )
7. Chest 'pain' aggravation by pressure on chest: no ( ), yes ( ), no chest pain ( )
8. Difference in leg circumference: no ( ), yes ( )

E. ECG

1. Q wave(s) (abnormal): no ( ), yes ( )
2. Time of ECG since onset of the episode (per A. 1. a): ____ hours
3. Chest 'pain' at time of ECG (per A. 1. a vs. A. 1. c. ii): no ( ), yes ( )
4. Maximum of ST elevation/depression in any lead: ____ mV
5. Hyperacute T (in more than one lead): no ( ), yes ( )
6. Arrhythmia, left bundle branch block, and/or (in any lead) T inversion: no ( ), yes ( )

F. Enzymes

1. Time of drawing blood since onset of episode (per A. 1. a. i): ____ hours

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2. Result:

   (a) myoglobin normal ( ), elevated ( )
   (b) troponin normal ( ), elevated ( )

Appendix B

Participating experts

Dr. C. Alfare, Uster; Dr. M. Sprenger, Uster; Dr. A. Chuffart, Männedorf; Dr. F. Widmer, Münsterlingen; Dr. C. Hoess, Münsterlingen; Dr. S. Christen, Zürich; Dr. P. Gerstl, Wetzikon; Dr. M. Liesch, Chur; Dr. N. Geigy, Liestal; Dr. T. Herren, Urdorf; Dr. M. Diethelm, St. Gallen; Dr. U. Hufschmid, Baden; Dr. F. Hess, Affoltern a.A.; Dr. L. Zimmerli, Zürich; Dr. S. Elsasser, Zollikerberg; Prof. W. Zimmerli, Liestal; PD Dr. D. Keller, Zürich; Dr. A. Oestmann, Bern; PD Dr. T. Brack, Glarus; Dr. P. Sidler, Zürich; Dr. A. Hurni, Altdorf; Dr. E. Achermann, Urdorf; Dr. D. Schneider, Aarau; Dr. B. Wieler, Affoltern a. A.; Dr. R. Jeker, Chur; Dr. Z. Schöpf, Altdorf; Dr. M. Graber, Wetzikon; Dr. H.P. Voegelin, Bülach; Dr. D. Grgic, Winterthur; Dr. P. Rochat, Frauenfeld; Dr. K. Shaik, Männedorf; and Dr. S. Nissle, Basel.