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Reporting practices of microbiology laboratories

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SUMMARY Results of investigations on typical specimens were circulated to Australian microbiologists, who were asked to draft reports on the basis of the data provided. Many laboratories were found simply to report the results of their activities without explanations. This was true whether the finding was that of a Gram-negative rod in a postoperative sputum or an anaerobic diphtheroid in a blood culture. There was diversity of views as to what constituted probable contamination in a urine specimen. Often no clearcut verdict was given, nor did the report indicate when no conclusion was possible. Remedial measures are discussed.

'Is it significant?' is the question posed, implicitly or explicitly, whenever a culture from a patient has yielded a micro-organism. 'How is this result to be explained to the clinician?' is an equally important question, as yet little discussed. Microbiology reports can be a fruitful source of clinical bafflement[1 2] and thus of wasted laboratory effort. These studies revealed considerable differences in the interpretation of laboratory reports by doctors, whether in general or in hospital practice, a situation which, it was suggested, could be at least partly remedied if microbiologists ensured that reports were free of jargon and if conclusions were stated more clearly. It was therefore important to determine how much care laboratories took to ensure that their reports were easily understood by the non-microbiologist and how much responsibility they took in the interpretation of results.

Survey

We circulated a set of laboratory records to the bacteriologist-in-charge at all the Australian hospitals of more than 100 beds and to a number of private pathology laboratories in Sydney. Each laboratory record gave a brief clinical history, a description of the specimen, the results of microscopic examination of the Gram stain or wet film where appropriate, the results of culture, identification procedures, and sensitivity tests. Those microbiologists whose normal responsibility it was to prepare reports were invited to write actual reports based on the data provided in exactly the same way as they would have, had the investigations been done in their laboratory. Ninety-six sets of reports (*ca* 18%) were sent back to us; in some cases a few replies could not be analysed. The responses provoked by several of these work records are analysed below.

CASE 1	A WOMAN AGED 65
Clinical notes:	Operated on for carcinoma of the bowel 10 days ago, afebrile, chest 'congested'. Some cough and sputum.
Specimen:	Sputum mucopurulent.
Microscopy:	Gram stain—a few pus cells; predominance of Gram-negative rods with some normal flora present.
Culture:	Blood agar aerobic—80% Gram-negative rod, 20% 'normal flora'. The Gram-negative rod was identified as *Escherichia coli*. The sensitivity of the organism to 10 different antibiotics was given.

The finding of Gram-negative rods in the sputum of a patient recovering from a major operation is a common one. Here, as often, nothing in the results of the laboratory examination suggests a strong possibility of Gram-negative pneumonia. We found previously[1] that to report the presence of a Gram-negative rod in sputum, indicating its antibiotic sensitivities but offering no explanations or comment, led to misunderstanding by four clinicians out of five. Microbiologists, too, seem to have some difficulties with such cases, since there was a remarkable variety of opinions on the appropriate way to report such a result (Table 1). Seven stated 'no pathogens

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Table 1 *Case 1: Gram-negative rod in sputum*

Antibiotic sensitivities reported	*Comments offered on significance of findings*				
	None	*'No likely pathogens'*	*'Over-growth'*	*'? Significance'*	*'Probably significant'*
No	19	7	10	12	0
Yes	34	0	5	5	4

isolated' without indicating what had grown on the plates. At the other extreme, four respondents reported the isolate with antibiotic sensitivities and added a comment that it was 'probably' or 'definitely' significant. Fifteen indicated that the presence of the organism was a result of 'colonisation' or 'overgrowth' (attributed to the use of antibiotics by some). Seventeen suggested that the significance of the isolate was questionable. There were some inconsistencies in these reports, as can be seen from Table 1, since 10 who commented 'overgrowth' or '? significance' issued sensitivity reports. Fifty-three laboratories offered no comment on the possible rôle of the *E. coli* and, of these, 34 set out the sensitivities.

In all, 50% of the respondents included the antibiotic susceptibilities in their reports, thus by convention suggesting a causal rôle for the isolate. Did they really consider that this patient was suffering from *E. coli* pneumonia? Surely the finding of a Gram-negative rod in sputum is at best equivocal, especially if accompanied by few polymorphs? Nevertheless only 12 microbiologists indicated that a diagnosis of infection could not be made on the laboratory findings alone.

CASE 2 A WOMAN AGED 68

Clinical notes: Burning and scalding and lower abdominal discomfort.

Specimen: Urine, mid-stream.

Microscopy: On uncentrifuged specimen: white cells 10-100, red cells < 10, epithelial cells < 10, all × 10^6/l.

Culture: Bacterial count 10^8/l (dipslide). Aerobic blood agar—50% *E. coli* and 50% *'Streptococcus faecalis'*. Results of biochemical identification tests on the *E. coli* isolate and of sensitivity tests on both organisms against tissue and/or urine levels of 13 antibiotics were given.

Of the 93 respondents, 51 reported 'mixed growth of a coliform and a streptococcus' or words to that effect, did not give the sensitivities, made no comment, and usually asked for the examination to be repeated (Table 2). Thirty-one reported full sensitivities on both organisms (3 with a comment 'consistent with urinary tract infection') and two reported sensitivities to *E. coli* only. Six simply asked for the test to be repeated. Only three people said 'repeat if clinically indicated'.

Thus the reports on this set of data range from 'infection' to 'contaminated specimen, no evidence of infection'. In most cases the conclusion reached by the laboratory was not clearly stated, although it was strongly implied by the usual laboratory conventions, for example, use of such terms as 'mixed growth' or the omission of sensitivities where contamination was thought likely. When sensitivities were reported, the significance of the result was often qualified by such comments as 'doubtful significance'. Even to ask for repetition of the test casts some doubt on the result. This request was made 59 times (15 times by people who reported antibiotic sensitivities of the organisms), and none of these respondents explained that the reason for this was suspected poor technique in collecting the first specimen or suggested that repetition of the test was necessary only if symptoms persisted.

CASE 3 A WOMAN OF 50

History: Painful right knee one week. Ampicillin 250 mg three times a day for two days.

Specimen: Aspirate from the knee.

Microscopy: Gram stain—no organism seen; a few pus cells.

Culture: Blood agar, aerobic and anaerobic; Chocolate agar, diphasic medium } No growth. Subculture of cooked meat medium after one week yielded a *Streptococcus* species, aesculin-negative and non-haemolytic. Sensitivities to 11 antibiotics were given.

Table 2 *Case 3: α-Haemolytic streptococcus in knee aspirate*

Antibiotic sensitivities reported	*Comments offered on significance of findings*						
	'No growth'	*'No significant growth'*	*No comment*	*Indirect comment*	*'? Contamination'*	*'? Significance'*	*'Probably significant'*
No	15	5	3	6	5	13	3
Yes	0	0	20	12	3	7	0

There was no sign of streptococci in the Gram stain of the aspirate, nor on various other media inoculated at the bedside or in the laboratory, so its appearance in cooked meat broth alone, and after one week, must be regarded with extreme suspicion. However, a possible explanation for its delayed appearance, if it is actually a pathogen, is the earlier course of antibiotics. The widely differing reports written by the respondents are summarised in Table 2. The comment 'probably significant' was offered by three respondents, who nevertheless omitted antibiotic susceptibilities from their reports. Most were noncommittal or cryptic, offering indirect hints as to the significance of the isolate, such as 'not on direct plating', 'growth from broth', 'in enrichment media only', etc. While the implication of accidental contamination is obvious to a microbiologist, we wonder whether this interpretation would suggest itself to the average clinician not well versed in the laboratory's cultural routines. Perhaps most disturbing is the fact that 15 of the respondents would reply 'no growth' and five 'no significant growth' (in a proportion of laboratories it is the practice to discard cooked meat after 48 hours, and this explanation was offered for the report by five respondents).

Thirty-two of the respondents were prepared to report the isolation of an α-haemolytic streptococcus and to issue sensitivities without making a clearcut statement as to the interpretation of the result. This streptococcus may well be a skin contaminant, but its pathogenicity cannot be excluded on *a priori* grounds. If the original specimen contained bacteria, their small numbers could be due to ampicillin therapy. As the microbiologist cannot achieve a definite conclusion, he must set the possibilities before the clinician so that the latter has all the available information on which to base his decisions.

CASE 4 A MAN AGED 61

Clinical notes: Fever, heart murmur, no clubbing, no splenomegaly.

Specimen: 8 sets of blood cultures taken over one week.

Culture:

8/8 Aerobic bottles	No growth at two weeks' incubation
6/8 Anaerobic bottles	

After 48 hours two thioglycollate broth bottles grew 'anaerobic diphtheroids'. These isolates were identified as *Propionibacterium acnes* (results of tests given).

P. acnes is part of the normal flora of the skin and is therefore most likely to be a contaminant when isolated from blood cultures. It has, however, been described as a causative organism of bacterial endocarditis.[3] Had the organism been found in four or six bottles, it would clearly have had to be very seriously considered as the pathogen that the clinicians were seeking. Its appearance in only two blood cultures is much more difficult to interpret. Probably the most likely explanation is faulty technique in specimen collection; however, the isolations certainly cannot be dismissed as irrelevant.

Four respondents solved the problem that this case posed by the ruthless expedient of reporting 'no growth' (see Table 3). This, of course, was simply not true. Five others reported 'no significant growth' or 'no pathogens isolated', while the remainder admitted the detection of 'anaerobic diphtheroids' or *P. acnes*. Twenty-five commented no further, 38 said 'possible or probable contaminant', and 15 said '? significance' (does the latter phrase raise the possibility of a causal rôle or does it cast doubt on it?). The laboratory worker writing this report must ask himself whether the clinician will know what *P. acnes* is and what its normal habitat is or how common anaerobic diphtheroids are. If he does this, then he will come, as only six did, to offer the clear comment, 'this isolate is likely to be a contaminant but has been reported as a cause of bacterial endocarditis'. This microbe was isolated from the mitral valve when it was subsequently removed at operation. Similar organisms were seen in Gram-stained histological preparations of the valve tissue.

Discussion

A microbiological test may be dissected into five phases:

1 specimen examination, culture, sensitivity testing, etc;

2 conclusions drawn by the microbiologist from the results;

Table 3 *Case 4: Propionibacterium acnes in a blood culture*

Comments offered on significance of findings					
'No growth'	*'No significant growth'*	*No comment*	*'? Contamination'*	*'? Significance'*	*Adequate comment*
4	5	25	38	15	6

3 communication of the microbiologist's conclusions to the clinician: the report;
4 interpretation by the clinician of the report;
5 effect on patient management.

Hitherto, virtually all interest has centred on phase 1. However, the later phases of the microbiological test are no less important and have so far attracted little attention from the microbiologist (or from anyone else). This survey has attempted to answer two questions (related to phases 2 and 3 above):

(*a*) How do different microbiologists interpret the same results?
(*b*) How do different microbiologists express their conclusions for the information of the clinical staff?

Clearly, we found more variation in the interpretation of laboratory results than appears desirable. In some cases this was presumably due to a reluctance to take any responsibility for interpretation. We find it difficult to believe, for example, that many microbiologists consider *E. coli* to be a common cause of pneumonia. Yet this organism was reported in sputum, and its antibiotic sensitivities were detailed by half the respondents. However, equally serious is the failure of the report to make it clear that in some cases the microbiologist cannot reach a conclusion, and that only the clinician can do so by integrating the laboratory data with information collected at the bedside. Thus, in cases 3 and 4, where no definitive judgement is possible on the basis of the laboratory data, an appreciable proportion of our colleagues were prepared to make a firm pronouncement. So many rare and unlikely organisms have in fact been isolated from blood, cerebrospinal fluid, and other normally sterile sites, under conditions which leave little doubt of their pathogenicity, that it is never justified, in our opinion, to conceal the isolation of an organism simply because it appears unlikely to play a rôle in the disease process. Yet, when reporting on the two specimens of this type in the survey, 19 respondents said 'no growth' and a further 10 'no significant growth' (although, as it happened, in one case subsequent events showed the isolate to be highly significant). It is also dangerous, though not equally so, simply to report the isolate and not to attempt to indicate to the clinician that the pathogenicity of the organism is by no means certain.

It will be suggested that refusal to report organisms which are very likely contaminants avoids clinical confusion and unnecessary antibiotic therapy. Nevertheless it is a dubious practice and one that appears peculiar to microbiology. The haematologist does not suppress a report that the haemaglobin is 8·0 g/dl simply because of the fear that the patient may be unnecessarily transfused. And no doubt those who conceal the presence of the α-haemolytic streptococcus in the knee aspirate will usually be right (95%, 99%?). But is this good enough when 100% accuracy can be achieved by writing two lines, such as 'in the aspirate the streptococcus was apparently present only in very small numbers and may well be a contaminant, although its delayed appearance could be accounted for by antibiotic therapy'. In dealing with specimens from normally sterile sites, the principle must be 'Report all positive findings and provide adequate explanations'.

When the specimen comes from a site with a normal flora, the microbiologist has to decide whether the culture represents in fact this flora or whether a pathogen or potential pathogen is present. He will be guided by such observations as whether more than one organism is present, whether very large numbers of a single organism are found, and whether there are signs of inflammation as well as bacterial overgrowth, etc. His knowledge of disease processes may tell him that a preponderance of a Gram-negative rod such as *E. coli* or *Proteus mirabilis* in sputum is a not uncommon sequel to antibiotic therapy or major illness and that it is not pathognomonic of pneumonia. Nevertheless he cannot be certain. If he decides to suppress this result he has no way of telling in what percentage of cases he will be wrong. It is therefore, in our view, much safer to report such unlikely pathogens and to add an explanatory comment. Every clinical decision is a choice of competing alternatives based on probabilities, consciously or unconsciously evaluated. If the reports we send to the clinician are already based on our assessment of probabilities and *he is unaware of this* and assumes that they have the same absolute validity as a haemaglobin or blood glucose estimation, he may be seriously misled.

In the replies to this survey, a number of reporting 'idioms' and conventions were in evidence. To indicate the identity of the isolate(s) and to include antibiotic sensitivities appears to say 'I think this organism is the cause of the patient's illness'. To substitute 'sensitivities available if required' indicates that the microbiologist considers the isolate probably to be without significance, but recognises a reasonable doubt. 'Growth only in enrichment media', 'no growth on direct plating', and similar phrases = 'I am not sure that the original specimen contained any bacteria and this isolate may be a contaminant'. 'Mixed growth of' = 'the specimen was probably contaminated and the result is unlikely to be significant'. These traditional phrases are a convenient substitute for accurate analysis and are the more undesirable as we already know that the clinician often does not understand their meaning.

We noted also that microbiologists (like clinicians) commonly ask for a test to be repeated if the result is unclear. It was often difficult to justify this request. To report 'overgrowth of a Gram-negative rod' and then say 'please repeat' suggests that the sputum specimen was in some way inadequate, although properly collected specimens also yield Gram-negative rods. To ask for repetition of a microurine because the original specimen appears to be contaminated is reasonable enough if the bacterial count is high but more than one organism is present and none predominates. If the bacterial count is of borderline significance, it is probably worthwhile pointing out this fact and suggesting that the test should be repeated only if it is clinically indicated. From the results of this survey a certain percentage of the increase in the workload of microbiology laboratories appears to be self-generated.

The survey has indicated deficiencies that lead to unsatisfactory and misleading reports:

1 concealment of inconvenient culture results;
2 failure to draw attention to the inadequacy of the specimen;
3 failure to comment on unusual or potentially misleading culture results;
4 a tendency to inflexible views on what is pathogenic;
5 comments phrased in such a way that only other microbiologists are likely to grasp the full implications;
6 the use of ill-defined reporting conventions, such as '? significance' when the exact nature of the implied doubt can readily be conveyed in a simple sentence;
7 failure to state a definite conclusion or to indicate when this was impossible.

We were led in fact to wonder whether clinical microbiologists compose reports for other clinical microbiologists rather than for the clinicians who actually put the requests to them.

Our conclusion is that microbiology laboratories pay more attention to their bench work than to their communications. Too many assumptions are made about the clinicians' microbiological knowledge. To submit a specimen to the laboratory is to request the laboratory's advice. Conclusions that the microbiologist draws from his laboratory work should be plainly stated, not encoded in cipher. If a fault is perceived in the specimen this should be pointed out. In short, every request submitted to the laboratory is a request for the microbiologist to draw on his knowledge and judgement. We believe that the effectiveness of the clinical microbiologist would be considerably increased if he did so.

Appendix

These are the interpretations of *one* clinical microbiology department, along the lines suggested in our discussion. We emphasise that disagreement with the *detail* of these interpretations should not detract from the central theme.

CASE 1

Macroscopic examination:	Mucopurulent sputum.
Microscopy:	Gram stain—a few pus cells; predominance of Gram-negative rods with some normal flora present.
Culture:	80% *E. coli*, 20% 'normal flora'.
Comment:	The predominance of *E. coli* is most likely to be due to antibiotic therapy. However, antibiotic sensitivities are available if clinical assessment suggests infection.

CASE 2

Microscopy:	White cells 10-100 $\times 10^6$/l; red cells $< 10 \times 10^6$/l; epithelial cells $< 10 \times 10^6$/l;
Culture:	Bacterial count 10^8/l. A mixed growth of a Gram-positive coccus and a Gram-negative rod.
Comment:	Most likely due to faulty specimen collection. If symptoms persist, a repeat examination, with careful collection, is suggested.

CASE 3 Preliminary report (after 48 hours)

Microscopy:	Gram stain—no organisms seen; a few pus cells.
Culture:	No growth on aerobic or anaerobic culture.
Final report:	A *Streptococcus* species (sensitive to ampicillin) was isolated from broth culture after one week's incubation.
Comment:	This organism may be a contaminant. The microscopy and culture results are not diagnostic of septic arthritis.

CASE 4

Culture:	2/8 anaerobic bottles grew *P. acnes*.
	6/8 anaerobic bottles, 8/8 aerobic bottles: No growth after two weeks
Comment:	This organism is likely to be a contaminant but has been reported as a cause of bacterial endocarditis.

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