Clinical question:

ACS-008-A: In patients with suspected ACS (P), does the use of computer-assisted ECG interpretation (I), compared with standard diagnostic techniques (emergency physicians) (C), increase accuracy of diagnosis (e.g. of NSTEMI/STEMI) (O)?

Is this question addressing an intervention/therapy, prognosis or diagnosis? DIAGNOSIS

State if this is a proposed new topic or revision of existing worksheet: NEW

Conflict of interest specific to this question:

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? NO

Search strategy (including electronic databases searched):

MEDLINE SEARCH
1. electrocardiogra$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 166600
2. exp Electrocardiography/ 155103
3. ecg.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 36515
4. exp Diagnosis, Computer-Assisted/ 36851
5. computer-assisted diagnosis.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 250
6. exp Myocardial Infarction/ 123272
7. myocardial infarction.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 149865
8. acs.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 5181
9. ami.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 9395
10. stemi.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 1280
11. (1 or 2 or 3) and (4 or 5) and (6 or 7 or 8 or 9 or 10) 320

From 320 titles 93 abstracts were reviewed and 33 papers identified for review.

EMBASE SEARCH
1. electrocardiogra$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 73771
2. exp Electrocardiography/ 32512
3. ecg.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 24922
4. Computer-Assisted Diagnosis,/ 5148
5. computer-assisted diagnosis.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 5182
6. exp Myocardial Infarction/ 106655
7. myocardial infarction.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 69910
8. acs.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 4795
9. ami.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 8078
10. stemi.mp. [mp=title, original title, abstract, name of substance word, subject heading word] 1401
11. (1 or 2 or 3) and (4 or 5) and (6 or 7 or 8 or 9 or 10)  
Of the 72 titles, 11 were duplicates from Medline. From 61 titles all abstracts were reviewed and 7 papers identified for review.

**COCHRANE SEARCH**

<table>
<thead>
<tr>
<th>ID</th>
<th>Search</th>
<th>Hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>(ecg):ti,ab,kw</td>
<td>3120</td>
</tr>
<tr>
<td>#2</td>
<td>(electrocardiogram):ti,ab,kw</td>
<td>2206</td>
</tr>
<tr>
<td>#3</td>
<td>(acs):ti,ab,kw</td>
<td>376</td>
</tr>
<tr>
<td>#4</td>
<td>(acute coronary syndrome):ti,ab,kw</td>
<td>1056</td>
</tr>
<tr>
<td>#5</td>
<td>(myocardial infarction):ti,ab,kw</td>
<td>11429</td>
</tr>
<tr>
<td>#6</td>
<td>(computer-assisted):ti,ab,kw</td>
<td>4999</td>
</tr>
<tr>
<td>#7</td>
<td>(( #1 OR #2 ) AND ( #3 OR #4 OR #5 ) AND #6)</td>
<td>36</td>
</tr>
</tbody>
</table>

From 36 titles (no systematic reviews) all abstracts were reviewed but no papers identified for review.

**MASTER ENDNOTE LIBRARY SEARCH**

Key words in “Any Field” included combinations of: computer assisted; ecg; electrocardiogram; acute coronary syndrome; chest pain, myocardial infarction.

2 additional papers selected for review

- **State inclusion and exclusion criteria**
  Inclusion criteria – Human studies, diagnostic-test evaluation papers, comparison of computer-assisted ECG diagnosis with clinician ‘gold standard’, ideally including ECGs from patients with ACS
  Exclusion criteria – Editorials, unpublished conference papers, narrative review articles.

- **Number of articles/sources meeting criteria for further review:**

42 articles were reviewed. Of these only 7 were included in the final worksheet, with the other 5 included papers identified through secondary references.

Reasons for exclusion of papers included: serial comparison of ECGs for infarct evolution\(^1\); mathematical models\(^2,3\) or computer-assisted AMI diagnosis based on clinical presentation, blood tests and ECG findings \(^4\); Bayes’ Theorem \(^5\) or more sophisticated neural networks \(^6\)
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Good</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint

*Italics = Animal studies*
# Evidence Neutral to Clinical question

<table>
<thead>
<tr>
<th>Good</th>
<th>Willems, 1991&lt;sup&gt;E&lt;/sup&gt;</th>
<th></th>
<th></th>
<th></th>
<th>Hillson, 1995&lt;sup&gt;E&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td>O'Rourke, 1992&lt;sup&gt;E&lt;/sup&gt;</td>
<td>Kudenchuk, 1991&lt;sup&gt;E&lt;/sup&gt;</td>
<td>Thomson, 1989&lt;sup&gt;E&lt;/sup&gt;</td>
<td></td>
<td>Tsai, 2003&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td>Poor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Snyder, 2003&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Goodacre, 2001&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = Return of spontaneous circulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B = Survival of event</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C = Survival to hospital discharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D = Intact neurological survival</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E = Other endpoint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Italics = Animal studies*

# Evidence Opposing Clinical Question

<table>
<thead>
<tr>
<th>Good</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td>Massel, 2003&lt;sup&gt;E&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>Sekiguchi, 1999&lt;sup&gt;E&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = Return of spontaneous circulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B = Survival of event</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C = Survival to hospital discharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D = Intact neurological survival</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E = Other endpoint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Italics = Animal studies*
Accurate and timely diagnosis of acute coronary syndrome (ACS) is important so that time to definitive care (thrombolysis or revascularisation procedures) is minimized. Cardiologists are regarded as the 'gold standard' for interpretation of ECGs – but it is not always feasible to have immediate access to a cardiologist, especially in the pre-hospital environment. Since the 1980s there has been interest in the clinical implications of computerised interpretation of ECGs – which if shown to be accurate - could either replace or at least supplement ECG interpretation by less experienced clinicians. If ambulance paramedics are to administer thrombolytic therapy (or to identify patients for direct transfer to a percutaneous coronary intervention (PCI) facility, in the absence of a medical practitioner, acute coronary occlusion with evolving myocardial infarction must be diagnosed with high specificity and acceptable sensitivity. Maximising specificity is critical to ensure that patients without ACS are not subjected to unnecessary and potentially risk-associated procedures. However, as pointed out by Massel et al, poor sensitivity results in potentially eligible thrombolysis (or other revascularization procedure) candidates being missed.

The ideal test of the diagnostic accuracy and clinical utility of computerized ECG interpretation programs in ACS patients would be to prospectively compare the diagnosis and treatment decisions of clinicians who had access to the ECG computerised report with those who didn’t – against a ‘gold standard’ such as expert electrocardiographer review. Such a study should ideally include a wide spectrum of patients in terms of age, gender and medical history and presenting symptoms (typical and non-typical history). There have been a number of reports of the diagnostic accuracy of computer-interpretation of (ECGs), although the focus in most instances has not been specifically on ACS ECGs nor on ascertaining the value added benefit of the computerized ECG report on clinician diagnosis in potential ACS patients.

Despite early enthusiasm about the clinical utility of the computerized ECG interpretation this has been tempered by recognition that measurements made by different automated ECG systems from reference ECG data can vary enough to alter diagnostic interpretation. Several factors have been shown to impact on the accuracy of the computer interpretation of the ECG, including electrode placement and patient positioning. When comparing the ECG interpretation of a cardiologist to a specific computer program (called ‘MEANS’) Schijvenaars et al found that the cardiologist was less affected by insignificant signal changes due to electrode shifts than the computer. It has also been shown that patient characteristics and clinical history can affect the clinician interpretation of the ECG – particularly in less expert readers. Hatala et al showed that clinical history had an influence on ECG diagnostic accuracy by physicians at all levels, both improving accuracy when the history suggests the correct diagnosis, and reducing accuracy when the history suggests an alternative diagnosis. They report that “provision of a correct history improved accuracy by 4% to 12% compared with no history, depending on level of training. Conversely, a misleading history compared with no history reduced accuracy by 5% for cardiologists, 25% for residents, and 19% for students.” Moreover there has been concern that the sensitivity of the interpretation program is influenced by infarct location, with sensitivity lower in anterior than inferior injury. The sensitivity and specificity of the AMI detection algorithm in the Marquette 12SL™ ECG interpretation program has been reported as having a sensitivity of 63% (for anterior AMI) and 91% (for inferior AMI) without loss of specificity (99%). However, the fact is that currently there is still unacceptable levels of patient delay in response to chest pain in many places in the world.
Salerno et al\textsuperscript{15} reviewed 13 reports of computer ECG program performance and showed that these programs generally perform less well than expert readers with respect to individual diagnoses. Even so, this report found that computer assistance was able to improve the diagnostic performance of less expert readers.\textsuperscript{15}

Within the current worksheet, considerable methodological heterogeneity within the body of literature was found, including: different ECG interpretation software used (and sometimes not identified); lack of uniformity in diagnostic criteria for AMI (especially in earlier studies) and variability in what is regarded as the 'gold standard' against which to test the accuracy of the computer-assisted programme. The computerized ECG report was compared with the interpretation of either a single or consensus view of cardiologists\textsuperscript{8, 16, 17} or so-called ‘expert electrocardiographers’\textsuperscript{18, 19} or as was the case in one study\textsuperscript{20}, ‘two accredited accident and emergency clinicians with extensive experience in ECG interpretation’. Four studies\textsuperscript{7, 10, 21, 22} used validated clinical diagnosis as the gold standard. It could be argued that the final clinical diagnosis is not an ideal ‘gold standard’ since it incorporates clinical data that possibly was not available to the ECG reader at the time of the initial presentation of the patient.

As identified above, many of the studies of the diagnostic accuracy of computer interpretation of the ECG incorporate a range of cardiac conditions and patient cohorts and do not specifically focus on interpretation of ECGs of ACS patients. Moreover, since, the positive (and negative) predictive value of a test is influenced by the prevalence of the condition in the population within which it is being tested, a number of the studies included in this worksheet attempted to ensure that their barrage of test ECGs reflected the prevalence of conditions likely to be found in that clinical context. Clearly though, there was considerable variation in the clinical cohorts used in the studies.

It has been suggested that perhaps the computerized ECG report might still provide useful information even it is not correct, ie a “second opinion that can be accepted or rejected by a physician”.\textsuperscript{17, p479} However the study by Tsai et al found that the impact of the computerized ECG report on nonexpert subject performance in interpreting ECGs depended on the correctness of the advice given.\textsuperscript{17} Similarly Hillson et al concluded that the effects of computer-assisted interpretation on clinical practice and decision making are complex, in that overall the computerized ECG report reduced ECG reading time and improved accuracy, but with some risk of clinicians being misled by incorrect computerized ECG report diagnosis.\textsuperscript{21} In addition, Massel et al suggested that “in the presence of a computerised ECG interpretation, the less experienced reader may be persuaded by the absence of the written prompt proclaiming an AMI, even if the ST segment elevation typical of acute injury is present.”\textsuperscript{8, p136}

Overall only two included studies\textsuperscript{18, 19} could be regarded as providing unqualified support for the concept that computer-assisted ECG interpretation improves the accuracy of ECG diagnosis, however neither specifically focused on ACS patients. The conclusion by Kligfield et al probably best sums up the literature to date, namely that whilst ECG technology has been evolving, and sensitivity and specificity of computer-based diagnostic statements improving, “there is generally consensus that physician overreading and confirmation of computer-based ECGs is required.”\textsuperscript{9, 1307} Similarly, Goodacre et al asserted that whilst computer generated ECG reports may have a role in prompting more junior doctors to query their own ECG interpretation, they “should not replace experienced medical support.”\textsuperscript{20, p457}
## SUMMARY OF EVIDENCE

### Support
- LOE D5: Woolley, 1992, p428: Fair
- LOE D5: Brailer, 1997, p80: Fair

### Neutral
- LOE D1: O'Rourke, 1992: Fair
- LOE D1: Kudenchuk, 1991, p1486: Fair
- LOE D1: Willems, 1991, p1767: Good
- LOE D5: Goodacre, 2001, p455: Fair
- LOE D5: Tsai, 2003, p478: Fair
- LOE D5: Snyder, 2003, p364: Fair
- LOE D1: Thomson, 1989, p428: Fair

### Oppose
- LOE D1: Massel, 2003, p131: Fair
- LOE D1: Sekiguchi, 1999, p75: Poor
Citation List


Notes
Brailer, 1997, p80
EVIDENCE= Support
LOE= D5 (not specifically ACS ECGs)
QUALITY= Fair
COMMENTS
Aim: To study how cardiologists’ use of CATI affects the accuracy and time of their ECG interpretations when reading batches of ECGs.
Subjects: 22 cardiologists who each read a total of 80 ECGs. Most read 50-100 ECGs per week and 20/22 stated that they used CATI more than 75% of the time.
ECG Test set: 40 pairs of clinically matched and difficulty-matched ECGs - one with CATI (computer-assisted test interpretation) and one without. Various diagnoses represented (not just ACS) - at frequencies that reflected the distribution of diagnoses in practice, including 20% 'normal'. All tracings were from a 'real' patient.
Gold standard: Five experts in electrocardiography
Outcomes Measured: Time to read each test ECG; interpretation of each test ECG - one primary and many secondary diagnoses allowed (written on ECG or initialing the CATI); certainty of their interpretation (Likert scale)
Results: No difference in subjects’ confidence in their interpretations between CATI and non-CATI ECGs. CATI ECGs were read, on average, 23 seconds (about 28%) faster than the non-CATI ECGs (Difference in Time). The CATI ECGs had significantly lower false-positive rates (Difference in False-positive Rate). The CATI ECGs also had significantly higher concordance scores (Difference in Concordance) = more correct interpretations.
Conclusions: CATI improves reading accuracy when ECGs have multiple diagnoses, just as it saves time.
Other comments: Scoring of outcomes and presentation of results complex. Artificial context - may / may not resemble real life decision making. Not clear what proportion of ECGs related to ACS therefore the paper does not specifically address the worksheet question.


Notes
Goodacre, 2001, p455
EVIDENCE= Neutral
LOE= D5 (not specifically ACS ECGs)
QUALITY= Fair
COMMENTS
Study to test the hypothesis that senior house officers (SHOs) in an accident and emergency department will make fewer errors of ECG interpretation if they are given ECGs with a computer generated report, compared with interpretation without such a report. A sample of 50 ECGs were collected using the Marquette M500 machine (Marquette Medical Systems Incorporated, Milwaukee, USA). A total of 10 SHOs were given one minute to analyse each of the 50 ECGs (half of which had ECG reports attached and half had no report), ie a total of 500 ECG interpretations. The "gold standard" for each ECG report was produced by two accreditedA&E clinicians with extensive experience in ECG reporting (consensus decision without reference to computer-generated report). Errors of interpretation by the SHOs were classified as 'major' and 'minor' by the senior clinicians - blind to whether the SHO had access to a computer-generated report or not.
Major errors were found in 46 out of the 250 ECG interpretations made by SHOs with access to the computer generated report (18.4%), compared with 56 out of the 250 interpretations made without a computer generated report (22.4%). (The Marquette M500 machine reported major errors in only 4% of ECGs.) Logistic regression showed no evidence of a relationship between use of a computer generated report and major errors of interpretation by the SHO, or between the use of a computer generated report and completely correct interpretation by the SHO.
Conclusions: There was no significant difference in the ECG error rate when junior doctors had assistance from computer generated reports, despite the computer having a lower major error rate than the SHOs. Computer generated ECG reports may have a role in prompting SHOs to query their own ECG interpretation - but should not replace experienced medical support.
Limitations: Only n=10 SHOs (but 500 ECGs); single hospital A&E; SHOs only had one minute to interpret each ECG (‘realistic or not). (ECG diagnosis not stated therefore uncertain if ACS patients’ ECGs included therefore the paper does not specifically address the worksheet question.)

Notes
Hillson, 1995, p107
EVIDENCE= Support
LOE= D5 (not only ACS ECGs)
QUALITY= Fair
COMMENTS
Aim: To examine the effects of computer-assisted interpretation (CI) of electrocardiograms on primary care physician diagnostic-decision making.
Design: Randomized controlled trial of n=40 primary care physicians randomly allocated to receive 10 brief clinical vignettes (based on actual episodes of care) and accompanying ECG either with or without the CI. (3 of the 10 CIs were wrong). Subjects asked to a) diagnose the patient problem; b) identify how confident they were of the diagnosis (1-10 likert scale); and c) state what other diagnoses they were considering. Total time taken (secs) looking at each ECG recorded by the researcher.
Gold-standard = the clinical diagnosis. Performance scored by two Internists - blinded to group (CI vs non-CI)
Results: The physicians who received the computer-generated reports with the ECGs spent an average of 46.7 seconds per ECG, while those who did not receive reports spent 61.9 seconds (p < 0.001). No difference in confidence level between the CI versus non-CI group. Confidence was unrelated to whether the subject’s diagnosis was consistent with the computer report. The subjects who received CI support agreed with the clinical diagnoses in 63 of 209 cases (30.1%), while those who did not receive CI support agreed with the clinical diagnoses in only 29 of 190 cases (15.3%), p = 0.004. (Overall, the proportion of cases in which the physician’s first-listed diagnosis agreed with the clinical diagnosis was rather low, at 23%) The two case vignettes that were substantially affected by CI represented somewhat unusual syndromes that were correctly identified by the CI reports (Wolff-Parkinson-White syndrome and pericarditis). The diagnoses reported by those who received CI support were more likely to be consistent with the CI reports (109 of 209 cases, 52.2%) than were the diagnoses of those who did not receive such support (64 of 190, 33.7%). Of the three incorrect CI reports, in only one vignette was there more likelihood of the CI group recording the CI incorrect diagnosis. Conclusions: The effects of computer-assisted interpretation on clinical practice and decision making may be complex. CI reduced ECG reading time and improved accuracy, however some risk of clinicians being misled by incorrect CI diagnosis.
Limitations ? clinical significance of a reduction in ECG reading time of 15 seconds. Assessment of likely patient management not possible. None of the vignettes related to ACS therefore the paper does not directly address the worksheet question.


Notes
Kudenchuk, 1991, p1486
EVIDENCE= Neutral
LOE= D1
QUALITY= Fair
COMMENTS
Aim: Evaluate and compare ECG interpretations by a computer algorithm and electrocardiographer - to a gold standard of final hospital diagnosis
Method: 1,189 ECGs were obtained from pre-hospital patients with chest pain of suspected cardiac origin who had no serious contraindication to thrombolytic therapy: 391=AMI (71% STEMI); 157=unstable angina; 641=no ACS
Results: Sensitivity (correctly identifying ACS ECGs) was higher for the electrocardiographer (66% versus 52%, p<0.001), whilst specificity (correctly identifying those without ACS) was higher for the computer interpretation (98% versus 95%, p<0.001). PPV for computer = 94% and electrocardiographer 86%; NPV for computer = 81% and electrocardiographer 85%. The electrocardiographer had a twofold higher (5%) false positive rate. Specificity of the computer algorithm was not influenced by patient characteristics, however gender did influence the specificity of the electrocardiographer (1% false positive diagnoses in women versus 8% in men)
Conclusions: (from paper) From the standpoint of initial triage of patients with chest pain, the computer could be viewed as 'safer' in excluding patients without acute myocardial infarction from inappropriate therapy.

Aim: To explore the impact of a computerized ECG interpretation, the clinical history and a thrombolysis eligibility checklist on observer variability and subsequent decision making (thrombolysis administration intention = yes/no).

Results: Inter- and intra-observer agreement was highest for the most experienced clinicians (cardiologists). Medical Residents took significantly longer to complete the reading sessions compared to the more experienced readers. The presence of a computerised ECG interpretation seemed to have, paradoxically, both good and bad influences. Among relatively inexperienced readers a computerised ECG interpretation resulted in an increased reliability of interpretation. However, this was achieved through decreased thrombolysis use overall, and a greater percentage of inappropriate underuse among scenarios where the ECG showed thrombolysis eligibility.

Conclusions: It was postulated that in the presence of a computerised ECG interpretation the less experienced reader may be persuaded by the absence of the written prompt proclaiming an AMI, even if the ST segment elevation typical of acute injury is present.

Limitations: Only 9 physicians assessed (3 cardiologists; 3 cardiology fellows; 3 medical residents)


Study design = 2 Phases. Phase I: Test the ability of 4 different combinations of ECG interpretative statements and ST segment change at point 'M' to accurately identify the 21 'true' AMI patients from the 505 non-AMIs. Phase II: Prospective evaluation of the ability of the selected criteria to correctly identify 32 /74 pre-hospital patients potentially considered for thrombolysis.

Results: The criteria that required an interpretive diagnosis of 'myocardial infarction possibly acute' (plus TIMI ST elevation) had a relatively lower sensitivity of 62% and a specificity of 98%. The criteria accepted required ST segment elevation according to TIMI criteria, with ST depression in reciprocal leads plus a comment on 'injury' or 'infarction' in the leads with ST segment elevation. In Phase I of the study - this resulted in 71% sensitivity and 98% specificity. In the prospective Phase II - the criteria achieved a sensitivity of 75% (24/32) and a specificity of 98% (41/42), with PPV 96% and NPV = 82%. A patient with a right bundle branch block was a false positive.

Conclusions: The ECG interpretation only formed part of the decision criteria for thrombolysis - which also included typical history, no previous infarction; no response to GTN; no pre-existing serious illness and no contraindication to thrombolysis - plus phone consultation with a cardiologist.

The computer interpretation of the ECG did not necessarily increase the accuracy of the diagnosis (compared to transmission of the ECG directly to the cardiologist by telemetry) - but it did demonstrate the potential to reduce time to thrombolysis.


Aim: To compare the clinical interpretation of ECGs between that obtained by the computer using the Marquette 12SL ECG analysis program versus physicians in training versus experienced cardiologists. The study was restricted to ECGs from patients whose diagnosis could be validated by non-electrocardiographic evidence, such as the results of cardiac catheterisation, echocardiography and measurements of serum cardiac enzymes. 1058 ECGs from patients (812 men) with a variety of diagnoses, including 54% normal ECGs. Analysed by 25 Physicians in training (2 years post Medical School)
Gold standard = ECG Diagnosis of three cardiologists

Results: Overall the False Negative (10.5% versus 3.7%) and False Positive (16.5% versus 0.9%) rate was higher for the computer analysis than it was for the physicians.

For the 14 MI ECGs: sensitivity was 100% ; Specificity was 99.8%; True Positive was 50% and True Negative was 100% for the Computer Analysis (no results provided for the Physicians). For the 29 ECGs with ST and/or T wave changes suggestive of MI: sensitivity was 76.6% ; Specificity was 100%; True Positive was 100% and True Negative was 99.8% for the Computer Analysis.(no results provided for the Physicians)

Conclusion (from paper): Computer analysis of ECGs can result in serious errors - particularly when analysing the ST-segment and T-wave. "...the physician must not delegate the interpretation of ECGs to the computer".

Limitations: Insufficient results provided to allow direct comparison of computer interpretation versus physician interpretation. (Only 14 ECGs for AMI and 29 ECGs for myocardial ischaemia - out of a total of n=1058 ECGs)


Notes
Snyder, 2003, p364
EVIDENCE = Neutral
LOE = D5 (not only ACS ECGs)
QUALITY = Fair
COMMENTS

Aim: To compare the accuracy of ECG interpretations by ED physicians and a computer generated interpretation to a reference standard.

Design: A clinical cohort of all pediatric patients (<22years) who had an ECG in one ED over one year. (Marquette electronics 12 SL software package generated the computer interpretations) The ED physicians interpreting the ECGs were directly involved in the patients’ care and were familiar with the presenting complaint, past medical history, and physical examination. Gold standard = ECG interpretation by a pediatric electrophysiologist - blinded to the ED physicians’ interpretation. A priori determination of the level of clinical significance: I, normal sinus rhythm; II, minimal clinical significance; III, indeterminate clinical significance; IV, those of definite clinical significance. A misinterpretation was defined as the omission of any class II to IV diagnosis present on the ECG.

Results: A total of 294 ECGs, containing 638 diagnoses (2.1 per ECG), were included in the study. No sig difference between accuracy of ED physicians and computer generated interpretation for Class I (all correct) and Class IV ECG diagnoses (both poor) - but for Class II and III - the computer interpretation was sig more accurate.

Conclusion: There was a significant discordance in the ECG interpretative accuracy between the ED physicians and the computer-generated report. The computer proved to be more accurate than the ED physicians in interpreting ECGs of less than critical significance. However, both failed to correctly identify the vast majority of the most significant ECG diagnoses (only 14% computer versus 28% for ED physicians).

Limitations: ACS uncommon in children (only 3 ECGs from AMI patients) so paper does not directly address the worksheet question. The potential effect of providing the ED physicians with the computerised ECG report was not tested.


Notes
Thomson, 1989, p428
EVIDENCE = Neutral
LOE = D1
QUALITY = Fair
COMMENTS

Aim: To determine the accuracy of computerised ECG diagnostic statements on ECGs conducted on patients, during the first 8-months of use at one teaching hospital.

Method The computerised ECG report (using the Hewlet-Packard ECG Management system (Version 5) from the first 5110 ECGs performed on consecutive patients at one hospital was reviewed by cardiologists for accuracy.

Results: For MI (frequency 33.5%) sensitivity ± standard error was 86.5% ±0.8% and specificity was 93.9% ±0.4% Positive predictive value = 87.5%±0.8%; Negative predictive value= 93.2% ±0.4%. For Normal Sinus Rhythm (frequency 86.2%) sensitivity ± standard error was 96.6% ±0.3% and specificity was 97.0% ±0.6%; Positive predictive value = 99.5%±0.1%; Negative predictive value= 81.9% ±1.3%

Conclusions: (From Paper) We conclude that the computerized analysis of electrocardiograms has a satisfactory predictive accuracy when used in an environment with a high prevalence of abnormalities. Electrocardiograms that are

---

Snyder, 2003, p364
EVIDENCE = Neutral
LOE = D5 (not only ACS ECGs)
QUALITY = Fair
COMMENTS

Aim: To compare the accuracy of ECG interpretations by ED physicians and a computer generated interpretation to a reference standard.

Design: A clinical cohort of all pediatric patients (<22years) who had an ECG in one ED over one year. (Marquette electronics 12 SL software package generated the computer interpretations) The ED physicians interpreting the ECGs were directly involved in the patients’ care and were familiar with the presenting complaint, past medical history, and physical examination. Gold standard = ECG interpretation by a pediatric electrophysiologist - blinded to the ED physicians’ interpretation. A priori determination of the level of clinical significance: I, normal sinus rhythm; II, minimal clinical significance; III, indeterminate clinical significance; IV, those of definite clinical significance. A misinterpretation was defined as the omission of any class II to IV diagnosis present on the ECG.

Results: A total of 294 ECGs, containing 638 diagnoses (2.1 per ECG), were included in the study. No sig difference between accuracy of ED physicians and computer generated interpretation for Class I (all correct) and Class IV ECG diagnoses (both poor) - but for Class II and III - the computer interpretation was sig more accurate.

Conclusion: There was a significant discordance in the ECG interpretative accuracy between the ED physicians and the computer-generated report. The computer proved to be more accurate than the ED physicians in interpreting ECGs of less than critical significance. However, both failed to correctly identify the vast majority of the most significant ECG diagnoses (only 14% computer versus 28% for ED physicians).

Limitations: ACS uncommon in children (only 3 ECGs from AMI patients) so paper does not directly address the worksheet question. The potential effect of providing the ED physicians with the computerised ECG report was not tested.


Notes
Thomson, 1989, p428
EVIDENCE = Neutral
LOE = D1
QUALITY = Fair
COMMENTS

Aim: To determine the accuracy of computerised ECG diagnostic statements on ECGs conducted on patients, during the first 8-months of use at one teaching hospital.

Method The computerised ECG report (using the Hewlet-Packard ECG Management system (Version 5) from the first 5110 ECGs performed on consecutive patients at one hospital was reviewed by cardiologists for accuracy.

Results: For MI (frequency 33.5%) sensitivity ± standard error was 86.5% ±0.8% and specificity was 93.9% ±0.4% Positive predictive value = 87.5%±0.8%; Negative predictive value= 93.2% ±0.4%. For Normal Sinus Rhythm (frequency 86.2%) sensitivity ± standard error was 96.6% ±0.3% and specificity was 97.0% ±0.6%; Positive predictive value = 99.5%±0.1%; Negative predictive value= 81.9% ±1.3%

Conclusions: (From Paper) We conclude that the computerized analysis of electrocardiograms has a satisfactory predictive accuracy when used in an environment with a high prevalence of abnormalities. Electrocardiograms that are
classified as normal by computerized analysis may not require checking; however, all electrocardiograms with abnormalities should be interpreted by a competent electrocardiographer.

Limitations: The effect of the computerised ECG recording on accuracy of the diagnosing clinicians was not tested.


Notes
Tsai, 2003, p478
EVIDENCE= Support
LOE= D5 (not specifically ACS EKGs)
QUALITY= Fair
COMMENTS

Subjects: n=30 internal medicine residents (2nd or 3rd year training)
Setting: Laboratory based
EKG Test set: 23 EKG tracings with 54 total findings (27 with CI and 27 without CI), 32 of which were correctly (59%) interpreted by the Computer Interpretation (CI) - divided into two sets (A and B).
Findings: (1) Overall, the CI had a positive influence on resident physicians' accuracy in interpreting the EKGs in this set. (2) The CI, when correct, increased the likelihood that the finding would be correctly interpreted (statistically significant) (3) The CI, when incorrect, decreased the likelihood that the finding would be correctly interpreted (NOT statistically significant). Subjects were more likely to write an interpretation that agreed with the incorrect CI almost twice as often when they were assisted by the computer than when they were not (67.7% vs. 34.6%)
Conclusion: The impact of the CI on nonexpert subject performance in interpreting EKGs depends on the correctness of the advice given.
Limitations: The authors suggest that the non-significant negative effect of the incorrect CI could be due to inadequate sample size. Only 5 out of the 54 findings directly related to MI.


Notes
Willems, 1991, p1767
EVIDENCE= Neutral
LOE= D1
QUALITY= Good
COMMENTS
Aim: To compare the performance of nine electrocardiographic computer programs with that of eight cardiologists (from 7 European countries) in interpreting ECGs in 1220 clinically validated cases of seven cardiac disorders, including patients with anterior myocardial infarction (n = 170), inferior myocardial infarction (n = 273), or combined myocardial infarction (n = 73) and n=382 controls.
Method: No clinical data were provided to the cardiologists (or entered into the program) except for age and sex of the patient. The 'gold standard' was clinical diagnoses made independently of the ECGs.
Results: Overall the percentage of ECGs correctly classified by the computer programs (median, 91.3 percent) was lower than that of the cardiologists (median, 96.0 percent; p<0.01). For the cardiologists, the median sensitivity for anterior MI was 84.9% (range 79.0 to 87.5%) compared to a median sensitivity of 77.1% (range 58.8% to 81.5%) for the computer-interpretation. For inferior MI the median sensitivity for cardiologists was 71.7% (range 59.2% to 84.1%) compared to 58.8% (range 38.7% to 82.8%) median sensitivity for the computer interpretations.
Conclusions: Most cardiologists had a better performance than the computer programs in confirming normality and a higher sensitivity in diagnosing anterior AMI. However, the results showed that the computer programs with the best performance were almost as accurate as the best cardiologists in classifying the ECGs of patients across the seven diagnostic groups.


Notes
Woolley, 1992, p428
EVIDENCE= Support
LOE= D5 (not specifically ACS)
QUALITY= Fair
COMMENTS
Aim: To compare the ECG interpretation of family physicians, computer interpretation and routine cardiology ECG review with the electrocardiographer (gold standard). To determine if any clinically significant errors in interpretation by the family physician could have been modified by reference to the computer report.

Method: 301 ECGs obtained using Hewlet-Packard 4750-A recorder on all patients who had an ECG ordered during an 11-month period in a family practice centre of a University hospital. Clinical significance of findings defined a priori as: none; minor; or major.

Results: Family Physicians 67% agreement with the reference standard (electrocardiographer) on diagnoses of potential clinical significance, compared to: Computer 88.0% agreement; and Cardiologist 91.0% agreement. The most common errors made by the Family Physicians were over-looking probable infarcts and noting infarcts and conduction abnormalities where they likely did not exist.

Conclusions: The authors concluded that "This study demonstrates that the computer program was effective in correcting most of the potentially significant ECG reading errors made by the Family Physicians."

Limitations: The study does not test whether the Family Physicians would have altered their reading of the ECG based on the computer ECG interpretations. There is no mention of the potential negative effects of being inappropriately influenced by an incorrect computer interpretation. Not clear what proportion of ECGs related to ACS therefore the paper does not specifically address the worksheet question.

Reference List

5. Aase O. Clinical experience with a decision support computer program using Bayes' theorem to diagnose chest pain patients. Cardiology 1999;92(2):128-34.