Smartwatch Algorithm for Automated Detection of AF

KHRS 2019, Walker Hill Hotel, Seoul.

경희 의대 김진배
Disclosure

• none
Occult atrial fibrillation (AF) timeline

Patient with no AF

Patient develops asymptomatic paroxysmal AF

Patient suffers index stroke

Patient develops asymptomatic paroxysmal AF

Paroxysmal AF becomes persistent AF. Pt may develop mild shortness of breath

AF not detected during inpatient EKG monitoring after stroke

AF diagnosed on prolonged cardiac monitoring with ILR

AF diagnosed during clinical encounter

Joseph Walker Keach et al. Heart 2015
At least a third of patients with AF are asymptomatic.

Only a fifth of symptomatic AF patients will have symptoms temporally related to their AF episodes.


High risk for asymptomatic AF

✓ Cryptogenic stroke population
✓ Intracardiac device population
✓ Elderly population

ESC guideline: 2016
5.1 Overt and silent atrial fibrillation

The diagnosis of AF requires rhythm documentation using an electrocardiogram (ECG) showing the typical pattern of AF: Absolutely irregular RR intervals and no discernible, distinct P waves. ECG-documented AF was the entry criterion in trials forming the evidence for these guidelines. By accepted convention, an episode lasting at least 30 s is diagnostic. Individuals with AF may be
**Current guideline of Screening**

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Opportunistic screening</strong> for AF is recommended by pulse taking or ECG rhythm strip in patients &gt;65 years of age.</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>In patients with TIA or ischemic stroke, screening for AF is recommended by short-term ECG recording followed by continuous ECG monitoring for at least 72 hours.</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>It is recommended to interrogate pacemakers and ICDs on a regular basis for atrial high rate episodes (AHRE). Patients with AHRE should undergo further ECG monitoring to document AF before initiating AF therapy.</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>In stroke patients, additional ECG monitoring by long-term noninvasive ECG monitors or implanted loop recorders should be considered to document silent atrial fibrillation.</td>
<td>IIa</td>
<td>B</td>
</tr>
<tr>
<td><strong>Systematic ECG screening</strong> may be considered to detect AF in patients aged &gt;75 years, or those at high stroke risk.</td>
<td>IIa</td>
<td>B</td>
</tr>
</tbody>
</table>
Extended monitoring of high risk patients

- Repeated daily ECG recordings increased the detection of silent, asymptomatic paroxysmal AF in an unselected Swedish population aged >75 years.

- Several patient-operated devices and extended continuous ECG monitoring using skin patch recorders have been validated for the detection of paroxysmal AF.

Uncovering Atrial Fibrillation Beyond Short-Term Monitoring in Cryptogenic Stroke Patients
Three-Year Results From the Cryptogenic Stroke and Underlying Atrial Fibrillation Trial

Johannes Brachmann, MD; Carlos A. Morillo, MD; Tommaso Sanna, MD; Vincenzo Di Lazzaro, MD; Hans-Christoph Diener, MD, PhD; Richard A. Bernstein, MD, PhD; Marylin Rymer, MD; Paul D. Ziegler, MS; Shufeng Liu, MS; Rod S. Passman, MD, MSCE

**Background**—Atrial fibrillation (AF) can be a cause of previously diagnosed cryptogenic stroke. However, AF can be paroxysmal and asymptomatic, thereby making detection with routine ECG methods difficult. Oral anticoagulation is highly effective in reducing recurrent stroke in patients with AF, but its initiation is dependent on the detection of AF. Cryptogenic Stroke and Underlying Atrial Fibrillation (CRYSTAL AF) is the first randomized study to report the detection of AF in cryptogenic stroke patients using continuous long-term monitoring via insertable cardiac monitors (ICM).

**Methods and Results**—Patients with prior cryptogenic stroke were randomized to control (n=220) or ICM (n=221) and followed for ≤36 months. Cumulative AF detection rates in the ICM arm increased progressively during this period (3.7%, 8.9%, 12.4%, and 30.0% at 1, 6, 12, and 36 months, respectively), but remained low in the control arm (3.0% at 36 months). This resulted in oral anticoagulation prescription in 94.7% of ICM patients with AF detected at 6 months, 96.6% at 12 months, and 90.5% at 36 months. Among ICM patients with AF detected, the median time to AF detection was 8.4 months, 81.0% of first AF episodes were asymptomatic, and 94.9% had at least 1 day with >6 minutes of AF.

**Conclusions**—Three-year monitoring by ICM in cryptogenic stroke patients demonstrated a significantly higher AF detection rate compared with routine care. Given the frequency of asymptomatic first episodes and the long median time to detection, these findings highlight the limitations of using traditional AF detection methods. The majority of patients with AF were prescribed oral anticoagulation therapy.

**Clinical Trial Registration**—Clinicaltrials.gov; Unique identifier: NCT00924638.
*(Circ Arrhythm Electrophysiol. 2016;9:e003333. DOI: 10.1161/CIRCEP.115.003333.)*
Extended screening with ILR in Cryptogenic stroke patients

Hazard Ratio (95% CI) = 8.8 (3.5, 22.2)
log-rank p-value < 0.0001

Table 3. Use of Oral Anti-Coagulation Therapy by Follow-Up Visit

<table>
<thead>
<tr>
<th>Follow-Up Visit</th>
<th>% On OAC (Sample Size N)</th>
<th>Difference [ICM–Control] (95% CI)</th>
<th>P Value (Fisher’s Exact Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICM</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>6 Months</td>
<td>10.1% (208)</td>
<td>4.6% (197)</td>
<td>5.5% (0.5%-10.6%)</td>
</tr>
<tr>
<td>12 Months</td>
<td>14.7% (197)</td>
<td>5.9% (185)</td>
<td>8.8% (2.8%-14.8%)</td>
</tr>
<tr>
<td>24 Months</td>
<td>26.1% (88)</td>
<td>5.6% (89)</td>
<td>20.5% (10.2%-30.9%)</td>
</tr>
<tr>
<td>36 Months</td>
<td>38.5% (26)</td>
<td>8.3% (24)</td>
<td>30.1% (8.4%-51.8%)</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; ICM, insertable cardiac monitor; and OAC, oral anticoagulation.
Handheld ECG

✓ In 2007, the launch of the Apple iPhone.

✓ In 2008, Dr David Albert created the AliveCor.

✓ In 2014, AliveCor announced that more than one million ECGs had been recorded using their devices.

✓ In 2017, FDA cleared the Kardia Band, lets you see the actual ECG.

REHEARSE-AF study

5846 Potential participants (5726 identified using GP databases, 120 invited following research centre attendance)

1272 Volunteered to participate

Letter of invitation

3305 Did not respond
1269 Declined invitation

Telephone call, research centre visit

268 Excluded for clinical or logistical reasons

1004 Enrolled

500 AliveCor (intervention arm)

501 Standard Care (control arm)

3 Excluded due to protocol violations

J Halcox, Circ 2017
Study Population

Individuals >65 years of age
CHADS-VASc score ≥2
not in receipt of OAC therapy without a known diagnosis of AF
permanent cardiac pacing implantation were recruited.

✓ Study group
  Single lead ECG recorded with the AliveCor device (iECG)
twice-weekly recording and transmission of a 30-second single-lead
iECG trace to a secure server

✓ Control group
  Routine care was done and followed up as normal by their general
  practitioner.

J Halcox, Circ 2017
REHEARSE-AF study

J Halcox, Circ 2017
Results

Kaplan-Meier plot showing the estimated detection probabilities for atrial fibrillation (AF) in each study arm over the 52 weeks of the trial.

P=0.004
## Results

### Predictors of AF

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Hazard Ratio (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/F sex</td>
<td>1.9 (0.9–4.5)</td>
<td>0.11</td>
</tr>
<tr>
<td>Age ≥75 y</td>
<td>2.3 (1.0–5.1)</td>
<td>0.04</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.91 (0.6–1.4)</td>
<td>0.68</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.1 (0.7–1.6)</td>
<td>0.79</td>
</tr>
<tr>
<td>Stroke or TIA</td>
<td>1.2 (0.6–2.5)</td>
<td>0.64</td>
</tr>
<tr>
<td>Arterial disease</td>
<td>1.5 (1.0–2.4)</td>
<td>0.05</td>
</tr>
<tr>
<td>CHADS-VASc score ≥4</td>
<td>2.3 (1.0–5.1)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*J Halcox, Circ 2017*
almost 4-fold increase of a diagnosis of AF of a year

a cost of $10780 (£8255) per additional AF diagnosis.
Smartwatch Algorithm for Automated Detection of Atrial Fibrillation

Joseph M. Bumgarner, MD, Cameron T. Lambert, MD, Ayman A. Hussein, MD, Daniel J. Cantillon, MD, Bryan Baranowski, MD, Kathy Wolski, MPH, Bruce D. Lindsay, MD, Oussama M. Wazni, MD, MBA, Khaldoun G. Tarakji, MD, MPH

ABSTRACT

BACKGROUND The Kardia Band (KB) is a novel technology that enables patients to record a rhythm strip using an Apple Watch (Apple, Cupertino, California). The band is paired with an app providing automated detection of atrial fibrillation (AF).

OBJECTIVES The purpose of this study was to examine whether the KB could accurately differentiate sinus rhythm (SR) from AF compared with physician-interpreted 12-lead electrocardiograms (ECGs) and KB recordings.

METHODS Consecutive patients with AF presenting for cardioversion (CV) were enrolled. Patients underwent pre-CV ECG along with a KB recording. If CV was performed, a post-CV ECG was obtained along with a KB recording. The KB interpretations were compared to physician-reviewed ECGs. The KB recordings were reviewed by blinded electrophysiologists and compared to ECG interpretations. Sensitivity, specificity, and K coefficient were measured.

RESULTS A total of 100 patients were enrolled (age 68 ± 11 years). Eight patients did not undergo CV as they were found to be in SR. There were 169 simultaneous ECG and KB recordings. Fifty-seven were noninterpretable by the KB. Compared with ECG, the KB interpreted AF with 93% sensitivity, 84% specificity, and a K coefficient of 0.77. Physician interpretation of KB recordings demonstrated 99% sensitivity, 83% specificity, and a K coefficient of 0.83. Of the 57 noninterpretable KB recordings, interpreting electrophysiologists diagnosed AF with 100% sensitivity, 80% specificity, and a K coefficient of 0.74. Among 113 cases where KB and physician readings of the same recording were interpretable, agreement was excellent (K coefficient = 0.88).

CONCLUSIONS The KB algorithm for AF detection supported by physician review can accurately differentiate AF from SR. This technology can help screen patients prior to elective CV and avoid unnecessary procedures.

(J Am Coll Cardiol 2018;71:2381-8) © 2018 by the American College of Cardiology Foundation.)
STUDY population.

Consecutive patients with a diagnosis of AF who presented for scheduled elective cardioversion.

Inclusion
age 18 to 90 years
willing to wear the KB before and after CV.
excluded all patients with an implanted pacemaker or defibrillator.
Methods

**CENTRAL ILLUSTRATION** Automated Atrial Fibrillation Detection Algorithm Using Novel Smartwatch Technology

The smartwatch strap with an electrode sensor that records heart rhythm

- Patient places thumb on the sensor to record rhythm
- The application utilizes an algorithm to differentiate sinus rhythm (SR) from atrial fibrillation (AF), or would label the recording as unclassified if it does not meet certain criteria
- The app informs the patient if AF is detected; the results are transmitted to the patient’s physician
Kardia Band
Methods

- pre-CV ECG followed immediately by KB recording.
- post-CV ECG was then obtained along with another KB recording.
- The KB tracing was automatically analyzed using the KB algorithm.
- This algorithm measures rhythm and P-wave
  - irregular rhythm and P wave absence in real time ➔ “possible AF.”
  - regular rhythms with P waves ➔ “normal”
  - rates <50 or >100 beats/min or if the recording is noisy or shorter than 30 s ➔ “unclassified”
FIGURE 3 Incorrect KB Interpretations Compared to Simultaneous ECG

A

B

C

JACC 2018
## Results

<table>
<thead>
<tr>
<th>KB Algorithm Interpretation</th>
<th>Electrophysiologist-Interpreted 12-Lead ECG</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AF/Flutter</td>
<td>SR</td>
<td>Noninterpretable</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>AF/flutter</td>
<td>63</td>
<td>7</td>
<td>0</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>SR</td>
<td>5</td>
<td>37</td>
<td>0</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Missing/unclassified</td>
<td>23</td>
<td>34</td>
<td>0</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>91</td>
<td>78</td>
<td>0</td>
<td>169</td>
<td></td>
</tr>
</tbody>
</table>

Sensitivity of 93% (63 of 68; 95% confidence interval: 86% to 99%), specificity of 84% (37 of 44; 95% confidence interval: 73% to 95%), and k coefficient of 0.77 (95% confidence interval 0.65 to 0.89).
## Results

### Unclassified KB Readings

<table>
<thead>
<tr>
<th>Electrophysiologist-Interpreted KB Reading</th>
<th>AF/Flutter</th>
<th>SR</th>
<th>Noninterpretable</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF/flutter</td>
<td>14</td>
<td>5</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>SR</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Missing/noninterpretable</td>
<td>9</td>
<td>9</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
<td><strong>34</strong></td>
<td><strong>0</strong></td>
<td><strong>57</strong></td>
</tr>
</tbody>
</table>

Sensitivity of 100% (14 of 14; 95% confidence interval: 77% to 100%)  
Specificity of 80% (20 of 25; 95% confidence interval: 64% to 96%)  
$k$ coefficient of 0.74 (95% confidence interval: 0.54 to 0.95)
## Results

<table>
<thead>
<tr>
<th>Method for interpreting the recording:</th>
<th>% of patients with interpretable results</th>
<th>Accuracy of AF diagnosis compared to 12 lead electrocardiogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>App algorithm only</td>
<td>66%</td>
<td>93% sensitivity; 84% specificity</td>
</tr>
<tr>
<td>Physician only</td>
<td>87%</td>
<td>99% sensitivity; 83% specificity</td>
</tr>
<tr>
<td>Recordings labeled as “unclassified” by the app algorithm when reviewed by physician</td>
<td>100%</td>
<td>100% sensitivity; 80% specificity</td>
</tr>
</tbody>
</table>

The accuracy of the KB algorithm for the detection of AF was comparable to ILR results.
Smartwatch Performance for the Detection and Quantification of Atrial Fibrillation

- SmartRhythm 2.0, a convolutional neural network, was trained on anonymized data of heart rate, activity level, and ECGs from 7500 AliveCor users.
- 24 patients with ICMs and a history of paroxysmal AF who simultaneously wore the AFSW with SmartRhythm 0.1 software.
- The primary outcome was sensitivity of the AFSW for AF episodes ≥1 hour.
- Secondary end points included sensitivity of the AFSW for detection of AF by subject and sensitivity for total AF duration across all subjects.
- Subjects with >50% false-positive AF episodes on ICM were excluded.
Smartwatch Performance for the Detection and Quantification of Atrial Fibrillation

**Training Cohort**
ECG data from 7,500 AliveCor users was used to train SmartRhythm 2.0 algorithm
- SmartRhythm 2.0 HR/Activity data
- Previously validated ECG classification algorithm

**Validation Cohort**
24 subjects with paroxysmal AF and ICM
>31,000 hours of simultaneous AFSW and ICM monitoring

**AF Sensing Watch:**
- 97.5% sens. for AF episodes
- 97.7% sens. for total AF duration
- 83.3% sens. for pts with any AF ≥ 1h
✓ The ICM detected 82 episodes of AF ≥1 hour with a total duration of 1127.1 hours.

✓ The SmartRhythm 2.0 neural network detected 80 episodes (episode sensitivity, 97.5%) with a total duration of 1101.1 hours (duration sensitivity, 97.7%).

✓ Three of the 18 subjects with AF ≥1 hour had AF only when the watch was not being worn (patient sensitivity, 83.3%; or 100% during time worn).
Detection of atrial fibrillation with a smartphone camera: first prospective, international, two-centre, clinical validation study (DETECT AF PRO)

Noé Brasier\textsuperscript{1,}\textsuperscript{†}, Christina J. Raichle\textsuperscript{1,}\textsuperscript{‡}, Marcus Dörr\textsuperscript{2,}\textsuperscript{,3}, Adrian Becke\textsuperscript{2}, Vivien Nohturfft\textsuperscript{2}, Stefan Weber\textsuperscript{4}, Fabienne Bulacher\textsuperscript{1}, Lorena Salomon\textsuperscript{1}, Thierry Noah\textsuperscript{1}, Ralf Birkemeyer\textsuperscript{5}, and Jens Eckstein\textsuperscript{1,6,*}

\textsuperscript{1}CMIO office, University Hospital Basel, Petersgraben 4, 4031 Basel, Switzerland; \textsuperscript{2}Department of Internal Medicine B, University Medicine Greifswald, Greifswald, Germany; \textsuperscript{3}German Centre for Cardiovascular Research (DZHK), partner site Greifswald, Greifswald, Germany; \textsuperscript{4}Department of Internal Medicine, University Hospital Regensburg, Regensburg, Germany; \textsuperscript{5}Herzklinik Ulm, Ulm, Germany; and \textsuperscript{6}Department of Internal Medicine, University Hospital Basel, Petersgraben 4, 4031 Basel, Switzerland
Index and middle fingers on a mobile iECG

PPG recording with a smartphone camera
Flow of participants in the DETECT AF PRO trial

672 Subjects assessed for eligibility

- 18 Subjects excluded
  - 5 Double acquisitions
  - 5 Missing PPG files
  - 3 Missing iECG files
  - 1 Age < 18 years
  - 4 Missing informed consent

654 Subjects were included

- 62 Subjects excluded
  - 43 Insufficient quality of PPGs
  - 17 Insufficient quality of iECGs
  - 1 Insufficient quality of PPG AND iECG
  - 1 Spontaneous conversion of heart rhythm

592 Subjects for final analysis

- 248 AF
- 344 SR
### Accuracy of the Heartbeats algorithm

<table>
<thead>
<tr>
<th>Test criterion</th>
<th>1-min analysis</th>
<th>3-min analysis</th>
<th>5-min analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (%)</td>
<td>89.9 (85.5–93.4)</td>
<td>91.3 (86.5–94.7)</td>
<td>91.5 (85.9–95.4)</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>99.1 (97.5–99.8)</td>
<td>98.7 (96.7–99.6)</td>
<td>99.6 (97.8–100)</td>
</tr>
<tr>
<td>No diagnosis (%)</td>
<td>6.7</td>
<td>13</td>
<td>32.2</td>
</tr>
<tr>
<td>CCR (%)</td>
<td>88.8</td>
<td>77.6</td>
<td>60.9</td>
</tr>
</tbody>
</table>

### Accuracy of the Kardia algorithm

<table>
<thead>
<tr>
<th>Test criterion</th>
<th>Value % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (%)</td>
<td>99.6 (97.9–100)</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>97.8 (95.3–99.2)</td>
</tr>
<tr>
<td>No diagnosis (%)</td>
<td>18.8</td>
</tr>
<tr>
<td>CCR (%)</td>
<td>82.2</td>
</tr>
</tbody>
</table>
Conclusion and future perspectives

✓ Screening of AF is of great importance in the prevention of ischemic stroke, which is a socially and medically substantial issue.

✓ Advance of technology and cost-savings systematic population screening for AF is becoming an increasingly feasible approach.

✓ All screening efforts will lead to greater AF awareness and detection, as well as an improvement in outcomes.
Thank you for your attention
Sinusrhythm

Pulse measurement

Minute 1

Minute 2

Minute 3

Minute 4

Minute 5

Pulse wave:

Symbolized R-spikes: ▲ Regular heartbeat  ▲ Irregular heartbeat (e.g., ectopic beat)  ▲ Extremely irregular heartbeat (absolute arrhythmia)

Eliminated disruptions:
If present

The R-spikes projected in the pulse waves have been artificially generated and do not correspond to the original shape of an ECG curve; they merely symbolize the trigger point of a detected heartbeat.
Sinusrhythm with premature beats

**Pulse measurement**

**Minute 1**

**Minute 2**

**Minute 3**

**Minute 4**

**Minute 5**

**Pulse wave:**
- Symbolized R-spikes: Regular heartbeat, Irregular heartbeat (e.g. ectopic beat), Extremely irregular heartbeat (absolute arrhythmia)

*The R-spikes projected in the pulse waves have been artificially generated and do not correspond to the original shape of an ECG curve; they merely symbolize the trigger point of a detected heartbeat.*

Kyung Hee University
Atrial fibrillation

Pulse measurement

Minute 1

Minute 2

Minute 3

Minute 4

Minute 5

Pulse wave:

Symbolized R-spikes:  
- Regular heartbeat  
- Irregular heartbeat (e.g., ectopic beat)  
- Extremely irregular heartbeat (absolute arrhythmia)

Eliminated disruptions:  
if present

The R-spikes projected in the pulse waves have been artificially generated and do not correspond to the original shape of an ECG curve; they merely symbolize the trigger point of a detected heartbeat.
Sinusrhythmus
Atrial fibrillation
Temporal trends of medical cost between 2006 and 2015

A. Korean NHIS total expenditure (million €)

B. total AF hospitalisation cost (million €)

C. the proportion of total AF hospitalisation cost to Korean NHIS total expenditure (%).

The total cost of care increased even after adjustment for inflation from €68.4 million in 2006 to €388.4 million in 2015, equivalent to 0.78% of the Korean NHIS total expenditure.

심방세동을 왜 치료해야 하나?

심방수축력 감소 (atrial systole) 제대로 수축하지 못하고 움찔 움찔한 잔뜩림을 보임

심방에서 혈액이 원활하게 흐르지 않음 → 혈액이 고임 → 혈액응고를 일으킴

심방수축감소로 심실에 혈액이 덜채워짐

Ventricle only ejects its contents

Decrease in ventricular filling: about 20%

심박출량 (심실에서 전신으로 보내는 혈액의 양) 감소

Coronary flow is diastolic
Diastole shortens due to tachycardia

Oxygen consumption increases
Supply decreases

뇌졸중!

심부전!

C$_2$HEST score for AF prediction

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Risk factor</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>C$_2$</td>
<td>CAD (1 point) / COPD (1 point)</td>
<td>1-2</td>
</tr>
<tr>
<td>H</td>
<td>Hypertension (1 point)</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>Elderly (Age ≥ 75, 2 points)</td>
<td>2</td>
</tr>
<tr>
<td>S</td>
<td>Systolic HF (2 points)</td>
<td>2</td>
</tr>
<tr>
<td>T</td>
<td>Thyroid disease (hyperthyroidism) (1 point)</td>
<td>1</td>
</tr>
</tbody>
</table>

Total points 0-8

- Chinese (n=471,446) AUC 0.75
- Korean (n=451,199) AUC of 0.65

240,459 French