Electrocardiography (ECG)

BRHS 30 year follow-up (Q30)

2010-2012

During the 30 year follow-up physical examination in 2010-2012 (Q30), the BRHS participants underwent a resting 12-lead electrocardiogram (ECG) using the Atria 6100 ECG Machine instrument. The ECG test involved attaching a number of small, sticky sensors called electrodes to the participant's arms, legs and chest. These were connected by wires to an ECG recording machine. The ECG recordings were analysed at the University of Glasgow using the Minnesota Coding Classification system which utilizes a defined set of measurement rules to assign specific numerical codes according to severity of ECG findings. The set of Minnesota codes obtained for each participant are listed in the table in section 1. The University of Glasgow's ECG Core Lab ECG Handling Protocol and the Minnesota Code Classification System for Electrocardiographic Findings used can be found in Appendix C.

Derived variables were obtained for Left Ventricular Hypertrophy (LVH), Right Ventricular Hypertrophy (LVH), Conduction defects (CD), MI or Ischaemia grade (MISH), Atrial fibrillation (AF), Atrial Flutter together and Atrial Tachycardia using ECG Minnesota codes in algorithms. These derived variables are included in the **BRHS 2010-12 (Q30) 30yr follow-up derived & adjusted variables files**.

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Appendices

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C. ECG Handling Protocol & The Minnesota Code Classification System for ECG findings

1. Minnesota codes

The ECG recordings were analysed using the Minnesota Coding Classification system which utilizes a defined set of measurement rules to assign specific numerical codes according to severity of ECG findings. The set of Minnesota codes obtained for each participant are listed in the table below.

Minnesota (ECG classification system) ECG FIELD code	BRHS VARIABLE NAME	Data access
ECG Count	Q30ECG_Count	Yes
Age	Q30ECG_Age	Yes
Heart Rate (bpm)	Q30ECG_Heart_Rate_bpm	Yes
P axis (degree)	Q30ECG_P_axis_degree	Yes
QRS axis (degree)	Q30ECG_QRS_axis_degree	Yes
T axis (degree)	Q30ECG_T_axis_degree	Yes
P duration (ms)	Q30ECG_P_duration_ms	Yes
QRS duration (ms)	Q30ECG_QRS_duration_ms	Yes
PR interval (ms)	Q30ECG_PR_interval_ms	Yes
QT interval (ms)	Q30ECG_QT_interval_ms	Yes
QTC interval (ms)	Q30ECG_QTC_interval_ms	Yes
Minnesota group1_L	Q30ECG_Minnesota_group1_L	Yes
Serial type1_1	Q30ECG_Serial_type1_1	Yes
Minnesota group1_P	Q30ECG_Minnesota_group1_P	Yes
Srial type1_2	Q30ECG_Srial_type1_2	Yes
Minnesota group1_A	Q30ECG_Minnesota_group1_A	Yes
Serial type1_3	Q30ECG_Serial_type1_3	Yes
Minnesota group2_1	Q30ECG_Minnesota_group2_1	Yes
No serial comparison	Q30ECG_No_serial_comparison1	Yes
Minnesota group2_2	Q30ECG_Minnesota_group2_2	Yes
No serial comparison	Q30ECG_No_serial_comparison2	Yes
Snnesota group3	Q30ECG_Snnesota_group3	Yes
No serial comparison	Q30ECG_No_serial_comparison3	Yes
Minnesota group4_L	Q30ECG_Minnesota_group4_L	Yes
Serial type1_4	Q30ECG_Serial_type1_4	Yes
Minnesota group4_P	Q30ECG_Minnesota_group4_P	Yes
Serial type1_5	Q30ECG_Serial_type1_5	Yes
Minnesota group4_A	Q30ECG_Minnesota_group4_A	Yes
Serial type1_6	Q30ECG_Serial_type1_6	Yes
Minnesota group5_L	Q30ECG_Minnesota_group5_L	Yes
Serial type1_7	Q30ECG_Serial_type1_7	Yes
Minnesota group5_P	Q30ECG_Minnesota_group5_P	Yes
Serial type1_8	Q30ECG_Serial_type1_8	Yes
Minnesota group5_A	Q30ECG_Minnesota_group5_A	Yes
Serial type1_9	Q30ECG_Serial_type1_9	Yes
Minnesota group6	Q30ECG_Minnesota_group6	Yes
No serial comparison	Q30ECG_No_serial_comparison4	Yes

Minnesota group7_1	Q30ECG_Minnesota_group7_1	Yes
Serial type1_10	Q30ECG_Serial_type1_10	Yes
Minnesota group7_2	Q30ECG_Minnesota_group7_2	Yes
No serial comparison	Q30ECG_No_serial_comparison5	Yes
Minnesota group8_1	Q30ECG_Minnesota_group8_1	Yes
No serial comparison	Q30ECG_No_serial_comparison6	Yes
Minnesota group8_2	Q30ECG_Minnesota_group8_2	Yes
No serial comparison	Q30ECG_No_serial_comparison7	Yes
Minnesota group8_3	Q30ECG_Minnesota_group8_3	Yes
No serial comparison	Q30ECG_No_serial_comparison8	Yes
Minnesota group8_4	Q30ECG_Minnesota_group8_4	Yes
No serial comparison	Q30ECG_No_serial_comparison9	Yes
Minnesota group9_L	Q30ECG_Minnesota_group9_L	Yes
Serial type1_11	Q30ECG_Serial_type1_11	Yes
Minnesota group9_P	Q30ECG_Minnesota_group9_P	Yes
Serial type1_12	Q30ECG_Serial_type1_12	Yes
Minnesota group9_A	Q30ECG_Minnesota_group9_A	Yes
Serial type1_13	Q30ECG_Serial_type1_13	Yes
Minnesota group9m_1	Q30ECG_Minnesota_group9m_1	Yes
No serial comparison	Q30ECG_No_serial_comparison10	Yes
Minnesota group9m_2	Q30ECG_Minnesota_group9m_2	Yes
No serial comparison	Q30ECG_No_serial_comparison11	Yes
LVMI Rautaharju	Q30ECG_LVMI_Rautaharju_	Yes
LVMI F. Huwez	Q30ECG_LVMI_F_Huwez	Yes
Summary_1	Q30ECG_Summary_1	Yes
Cornell Index (µV)	Q30ECG_Cornell_Index_V	Yes
Cornell Product (µV.S)	Q30ECG_Cornell_Product_VS	Yes
Sokolow-Lyon (µV)	Q30ECG_Sokolow_Lyon_V	Yes
QRS voltage sum (µV)	Q30ECG_QRS_voltage_sum_V	Yes
QRS voltage prod (µV.S)	Q30ECG_QRS_voltage_prod_VS	Yes
System date- day	Q30ECG_SYS_DATE_D	Yes
System date -month	Q30ECG_SYS_DATE_M	Yes
Systen date - year	Q30ECG_SYS_DATE_Y	Yes
Received date - day	Q30ECG_RECEIVED_D	Yes
Received date - month	Q30ECG_RECEIVED_M	Yes
Received date - year	Q30ECG_RECEIVED_Y	Yes

1. Derived variables using ECG Minnesota codes

These derived variables are included in the BRHS 2010-12 (Q30) 30yr follow-up derived and adjusted variables files.

Derived variables using SAS code1 Description	Value label	BRHS Variable name	Reference algorithm:	Data access
MI or Ischaemia grade Classified using Minnesota codes from ECG	1='definite MI - acute' 2='definite MI' 3='probable MI' 4='definite ischaemia' 5='probable ischaemia' 6='possible ischaemia'	q30ecg_mish	SAS code[1] (Appendix 1)	yes
Left Ventricular Hypertrophy Classified using Minnesota codes from ECG	1 = definite LVH 2 = probable LVH 3 = possible LVH	q30ecg_lvh	SAS code[1] (Appendix 1)	yes
Right Ventricular Hypertrophy Classified using Minnesota codes from ECG	1 = definite RVH 2 = probable RVH 3 = possible RVH	q30ecg_rvh	SAS code[1] (Appendix 1)	yes
Conduction defects based on Minnesota codes LBBB = Left Bundle Branch Block RBBB = Right Bundle Branch Block CHB = Complete Heart Block WPW= Wolff Parkinson White syndrome	1 = LBBB 2 = RBBB 3 = CHB 4 = WPW 5 = LBBB and WPW 6 = RBBB and CHB	q30ecg_cd	SAS code[1] (Appendix 1)	yes
Atrial Fibrillation only	1=yes, 0=no	Q30atrial_fibr	NOTE 1	yes
Atrial Flutter only	1=yes, 0=no	Q30atrial_flutter	NOTE 1	yes
Atrial Tachycardia only	1=yes, 0=no	Q30tachycardia	NOTE 1	yes
Atrial Fibrillation OR Fluter	1=yes, 0=no	Q30atrial_fib_flu	NOTE 1	yes
Atrial Fibrillation OR Flutter OR Tachycardia	1=yes, 0=no	Q30atrial_fib_flu_tac	NOTE 1	yes

Appendix A - Algorithms

SAS code[1] deriving:-

Left Ventricular Hypertrophy (LVH)
Right Ventricular Hypertrophy (RVH)
Conduction defects (CD)
MI or Ischaemia grade (MISH)

```
ecg=1;
if p_axis lt -327 then p_axis = .;
if qrs_axis lt -327 then qrs_axis= .;
if t_axis lt -327 then t_axis= .;
/*  to remove certain LBBBs       */
if ((mg1_l ge 110 and mg1_l le 119) or  (mg1_p ge 110 and mg1_p le 119)  or  (mg1_a ge 110 and mg1_a le 119)) or
((mg1_l ge 121 and mg1_l le 126)  or  (mg1_p ge 121 and mg1_p le 126)  or  (mg1_a ge 121 and mg1_a le 126)) and
mg7_1=711 then mg7_1=740;
```

*** CREATE Left Ventricular Hypertrophy using Minnesota codes * (LVH) ;**

```
if ecg=1 then lvh=0;
if (mg3 = 310 or mg3 = 330) and (mg4_l = 412 or mg4_l = 420 or mg4_p = 412 or mg4_p = 420 or mg4_a = 412
or mg4_a = 420 or mg4_a=411 or mg5_l = 510 or mg5_l = 520 or mg5_p = 510 or mg5_p = 520 or mg5_a = 510
or mg5_a = 520) then lvh=1;
if mg3 = 310 and lvh ne 1 then lvh = 2;
if mg3 = 330 and lvh ne 1 then lvh = 3;
```

*** CREATE Conduction defects using Minnesota codes * (CD);**

```
cd=.;
if mg7_1 = 711 then cd=1;
if mg7_1 = 721 then cd=2;
if mg6 = 610 then cd=3;
if mg6 = 641 then cd=4;
if mg7_1 = 711 and mg6 = 641 then cd=5;
if mg7_1 = 721 and mg6 = 610 then cd=6;
```

*** CREATE MI or Ischaemia grade using Minnsesota codes * (MISH);**

```
if ecg = 1 then mish=0;
if (mg4_l ge 430 and mg4_l le 439) or (mg4_p ge 430 and mg4_p le 439) or (mg4_a ge 430 and mg4_a le 439)
or (mg5_l ge 530 and mg5_l le 549) or (mg5_p ge 530 and mg5_p le 549) or (mg5_a ge 530 and mg5_a le 549)
then mish=6;
if (mg4_l ge 420 and mg4_l le 429) or (mg4_p ge 420 and mg4_p le 429) or (mg4_a ge 420 and mg4_a le 429)
or (mg5_l ge 520 and mg5_l le 529) or (mg5_p ge 520 and mg5_p le 529) or (mg5_a ge 520 and mg5_a le 529)
then mish=5;
if (mg4_l ge 410 and mg4_l le 419) or (mg4_p ge 410 and mg4_p le 419) or (mg4_a ge 410 and mg4_a le 419)
or (mg5_l ge 510 and mg5_l le 519) or (mg5_p ge 510 and mg5_p le 519) or (mg5_a ge 510 and mg5_a le 519)
then mish=4;
if (mg1_l ge 121 and mg1_l le 127) or (mg1_p ge 121 and mg1_p le 127) or (mg1_a ge 121 and mg1_a le 127)
then mish=3;
if ((mg1_l ge 110 and mg1_l le 119) or (mg1_p ge 110 and mg1_p le 119) or (mg1_a ge 110 and mg1_a le 119))
or ((mg1_l ge 121 and mg1_l le 127) or (mg1_p ge 121 and mg1_p le 127) or (mg1_a ge 121 and mg1_a le 127)) and
((mg5_l ge 510 and mg5_l le 539) or (mg5_p ge 510 and mg5_p le 539) or (mg5_a ge 510 and mg5_a le 539)) then
mish=2;
if ((mg1_l ge 110 and mg1_l le 119) or (mg1_p ge 110 and mg1_p le 119) or (mg1_a ge 110 and mg1_a le 119))
or ((mg1_l ge 121 and mg1_l le 127) or (mg1_p ge 121 and mg1_p le 127) or (mg1_a ge 121 and mg1_a le 127)) and
((mg9_l ge 920 and mg9_l le 929) or (mg9_p ge 920 and mg9_p le 929) or (mg9_a ge 920 and mg9_a le 929)) then
mish=2;
if ((mg9_l ge 920 and mg9_l le 929) or (mg9_p ge 920 and mg9_p le 929) or (mg9_a ge 920 and mg9_a le 929)) and
mish=2 then mish=1;
if ecg ne 1 then mish = .;
```

*** CREATE Right Ventricular Hypertrophy using Minnesota codes * (RVH);**

```
if ecg=1 then rvh=0;
if mg3=320 then rvh=3;
if mg3=320 and (mg4_l = 420 or mg4_p = 420 or mg4_a = 420 or mg5_l = 520 or mg5_p = 520 or mg5_a = 520)
then rvh = 2;
if mg3=320 and (mg4_l = 412 or mg4_p = 412 or mg4_a = 412 or mg4_a = 411 or mg5_l = 510 or mg5_p = 510 or
mg5_a = 510) then rvh = 1;
```

*** DERIVED ECG VARIABLES FOR Q30: *;**

```
q30ecg_mish=mish;
q30ecg_lvh=lvh;
q30ecg_rvh=rvh;
q30ecg_cd=cd;
*END*;
```

Appendix B

NOTE 1:

Deriving Atrial Fibrillation(AF), Atrial Flutter together, Atrial Tachycardia

Atrial fibrillation (AF)	was defined as Minnesota codes 8.3.1 and 8.3.3.
Atrial flutter	was defined as Minnesota codes 8.3.2 and 8.3.4
Atrial tachycardia	was defined as Minnesota codes 8.4.1 and 8.4.2
Atrial Fibrillation OR Flutter	was defined as Minnesota codes 8.3.1 to 8.3.4
Atrial Fibrillation OR Flutter OR Tachycardia	was defined as Minnesota codes 8.3.1 to 8.3.4 and 8.4.1, 8.4.2

APPENDIX C

BRITISH REGIONAL HEART STUDY ECG REQUIREMENTS

Atria 6100 ECG Machine Data Entry

British Regional Heart Study ID = **HsXXXXXX** (study prefix **H** in upper case and **s** in lower case) followed by 6/7 digit ID number)

First Name – initial only e.g. J (upper case)

Last Name – full surname e.g. SMITH (upper case)

Date of Birth – enter in format DD MM YYYY e.g. 21 12 1972

Age (this is calculated automatically once date of birth has been entered)

Sex (M or F)

Medication (relevant e.g. betablockers)

Clinical Class (relevant e.g. hypertensive)

ECG printout

Diagnostic text is visible on British Regional Heart Study hard copy ECGs. If you have any concerns about an ECG, check the ECG Faxing Guidelines (Addendum A), fax the ECG to the Clinical Trials Manager, Louise Inglis (tel/fax 0141 552 7089) who will arrange for it to be urgently reviewed. Addendum A of the protocol provides guidelines on when it is appropriate to fax an ECG to Glasgow. Please provide any additional relevant information on the fax cover sheet. The Clinical Trials Manager will respond either by email or telephone to confirm if any action is required. Any Abnormal ECGs which require referral to a GP will be scanned or faxed by the ECG Core Lab once the automated ECG has been received, processed and confirmed by Professor Macfarlane or in his absence, another Consultant Cardiologist. The scanned or faxed copy will be sent to UCL to be managed by BRHS.

Transmitting* ECGs */ Management of Data Queries

ECGs must be transmitted daily to the ECG core lab. BEFORE transmitting ECGs, print a copy of the Patient Directory Printout and check for any obvious data query e.g. missing study prefix or missing or incorrect digit in the ID. CORRECT errors before transmission to the ECG core lab. NOTE: errors in name or ID number can only be corrected prior to transmission. If a data query is recognised after transmission, inform the Clinical Trials Manager by email (louise.inglis@clinmed.gla.ac.uk). To provide an audit trail, data queries are managed by email and each query is given a separate identity number, e.g. DQ1001 - see Addendum B of the ECG protocol for full details. Data queries should be resolved as promptly as possible.

ECG Serial Comparison

ECGs will be automatically serially compared where a previous ECG is available on the ECG system. As appropriate, Professor Macfarlane will note a serial comparison comment on the Minnesota code sheet e.g. 'NSC' will indicate no significant change between the current and previous ECG. If the Minnesota codes are edited, a photocopy of the Minnesota code sheet with Professor Macfarlane's comment will be attached to the 'Confirmed' ECG and code sheet and sent with the normal batches of ECGs.

Troubleshooting ECG Recording

C.A.R.E. Website: http://www.gla.ac.uk/care provides ECG recording demonstration and troubleshooting tips or use Computerised Reporting of ECGs (C.A.R.E.) Manual. Alternatively, contact staff at the ECG core lab.

Technical Difficulties

If unable to transmit ECGs on day of recording, try the following day but if still unable to transmit ECGs, BRHS staff must contact the ECG core lab Clinical Trials Manager / IT Systems Manager that day and report the fault either by email or telephone to get the problem resolved quickly.

ECG Core Lab Main Contact

Louise Inglis, Clinical Trials Manager / Quality Manager
tel/fax/answering machine: 0141 552 7089, GRI Hospital Page 211 4000, Pager 3923
email: louise.inglis@clinmed.gla.ac.uk

APPENDIX C

ECG Core Lab Technical support

Shahid Latif, IT Systems Manager
tel: 0141 211 4860 email: s.latif@clinmed.gla.ac.uk

BRITISH REGIONAL HEART STUDY
ECG Core Lab ECG Handling Protocol

1. Introduction

The ECG Core Lab in Glasgow will manage, review and Minnesota Code 12 lead/25 mm/s ECGs for all participants enrolled into the British Regional Heart Study (BRHS). BRHS staff are responsible for sending the ECG Core Lab, by telephone transmission, good quality ECG recordings with correct participant ID and demographic data.. Each ECG received at the ECG core lab will be reviewed and assessed by Professor Peter Macfarlane (ECG Core Lab Director) or in his absence, when an immediate report is required, a Consultant Cardiologist, and the 'Confirmed' copies sent to the main study centre at University College London (UCL) Medical School on a monthly basis. Professor Macfarlane will also review the Minnesota Codes assigned to each ECG by the Glasgow computer system and edit them if required. A second copy of all ECGs with tracking list sheet will be sent to BRHS which will be sent to GPs by BRHS. Professor Macfarlane will provide a serial comparison comment on the Minnesota code sheet where there is an automated copy of the previous and current ECG.

2. Transmission of ECGs

Good quality 12 lead / 25 mm/s ECGs should be recorded and transmitted over the telephone network to the ECG core lab at the enrolling study centre on a daily basis.

2.1 Receipt of Faxed ECGs

The Clinical Trials Manager should be informed by email or telephone, in advance, when a faxed ECG is being sent for urgent review and/or if it is a 'not saved' ECG which requires review and manual Minnesota coding. BRHS centres should ensure that all faxed ECGs have the correct study ID, name, sex, age and ECG recording date/time visible on the ECG or put this information on an associated fax cover sheet. Please provide any additional useful information on the fax cover sheet, e.g. in the case of a participant's ECG showing Atrial Fibrillation – note: 'no previous history of heart rhythm abnormality' or 'patient not on any treatment' and similarly for myocardial infarction.

2.2 Faxed Urgent ECGs

The ECG core Lab Director or in his absence, a Consultant Cardiologist, will review any 'urgent' ECGs faxed to the Clinical Trials Manager. The type of ECG which should be faxed is dependent on the study participant's symptoms and/or the ECG text and summary content printed on the ECG. Guidelines on the type of ECG which should be faxed are noted in document ECG Faxing Guidelines / Addendum A. A copy of this document is provided by the ECG Core Lab. The report on a faxed ECG will be indicated to the study centre either by email or telephone on the same day that it is received (but normally within 2 hours of receipt). The ECG will be initialled by the reviewer and either 'No action required' or the type of 'Referral' written on the ECG report, as appropriate.

3. Referral ECGs

If an ECG (either automated or faxed copy) is reviewed and 'Referral to GP' or 'Referral to Cardiologist' is recommended, BRHS will be informed either by email or by telephone as soon as possible. A copy of the 'Confirmed' automated ECG indicating the Referral recommendation, e.g. 'Refer to GP', 'Refer to Cardiologist' etc., will be inserted into the text on the ECG. The Confirmed ECG will be faxed / scanned to the BRHS team if the Referral is considered to be required in the relatively near future.

4. Managing ECG Data Queries

The Clinical Trials Manager at the ECG Core Lab will enter data queries regarding an ECG with any missing or incorrect data on an Access database. Each query managed by the ECG core lab will be allocated a query number, e.g. DQ1209. BRHS team will be contacted by email regarding a query and the query number will be included in the email subject. Minimal study participant information should be

included in emails, e.g. ID number only, date and time of recording of ECG. When full study participant demographic 'sensitive' information is required, either by the ECG core lab, study centre or UCL, for Data Protection purposes all parties should protect the 'sensitive' information, e.g. name, sex, and date of birth. This type of information should be inserted into a 'password protected' Word document and attached to the query email. The 'password' will have been agreed and arranged with UCL. Information on how to manage password protected documents is detailed below in Addendum B. BRHS should respond and resolve data queries in a timely manner (preferably within 1-2 days of receipt). As required, the Clinical Trials Manager may also contact a study centre directly by telephone, fax or email to clarify a data query.

5. Sending Paper Copy ECGs to University College London (UCL) Medical School

The automated paper copy ECGs are sent in batches to Lucy Lennon / Jane Cryer at UCL on a monthly basis by the Clinical Trials Manager at the ECG Core Lab. At the beginning of a month, the previous month's batches of ECGs are checked for signature, serial comment (where appropriate), confirmation that data queries are resolved and that any edits have been appropriately carried out. The serial comparison comment will be noted on the Minnesota code sheet. If the Minnesota codes are edited, a photocopy of the Minnesota code sheet with Professor Macfarlane's comment will be attached to the 'Confirmed' ECG and code sheet and sent with the normal batches of ECGs. A daily tracking list of all ECGs received during that month is sent with the batches of ECGs. Any 'not saved' ECGs which have been faxed are sent with the automated batches of ECGs. A second copy of each ECG with a copy of the daily tracking list will be included to be used for sending to GPs. Prior to posting, an email is sent to UCL indicating the date and number of ECGs received each day for the appropriate month. An email confirming receipt of the monthly batch of ECGs is requested from BRHS.

6. Monthly Digital ECG Data

The IT Systems Manager at the ECG Core Lab is responsible for sending the digital ECG list and results files to Lucy Lennon / Jane Cryer at UCL. The list file and result file for ECGs received in the previous month are sent to BRHS on a monthly basis. The list file contains patient demographics and the results file contains the Minnesota codes for the ECGs received in the previous month. The IT Systems Manager creates the results and list file once the Clinical Trials Manager has confirmed that all the ECGs for the previous month have been reviewed, data queries have been resolved and editing has been carried out. The data files are created and then encrypted using WinZip and sent electronically to BRHS by the IT Systems Manager. An email confirming receipt of the monthly digital ECG data is requested from the BRHS staff.

7. ECG Core Lab Contact Details

First point of contact:
Louise Inglis, Clinical Trials Manager
Tel: 0141 552 7089, Email: louise.inglis@clinmed.gla.ac.uk

Fax number for receipt of faxed ECGs:
Tel: 0141 552 7089

Contact for ECG technical problems / Digital ECG Data:
Shahid Latif, IT Systems Manager
Tel: 0141 211 4860 Email: shahid.latif@clinmed.gla.ac.uk

ECG Core Lab Director
Professor Peter W Macfarlane
Tel: 0141 211 4724, Email: peter.w.macfarlane@clinmed.gla.ac.uk

8. Storage of Data

All electronic and paper documentation relating to the British Regional Heart Study will be appropriately retained and filed. Paper documentation will be filed in a designated filing cabinet and stored in a secure alarmed location. The electronic and paper documentation will be made available for audit, as required.

APPENDIX C

BRHS ECG FAXING GUIDELINES

ADDENDUM A

ECGs which have the following statements only, even in combination, <u>do not</u> require to be faxed urgently to Glasgow:
Rhythm
Possible ectopic atrial rhythm
Supraventricular extrasystoles
Borderline first degree AV block
First degree AV block where PR < 240 ms [PR interval is printed on the report]
Atrial Abnormality
Possible left atrial abnormality
MI
Possible old inferior myocardial infarction
Possible inferior infarct – age undetermined
Other QRS
Possible right ventricular hypertrophy
Poor R wave progression – etc.
ST Elevation
Consider pericarditis
Extensive ST elevation suggests pericarditis
Possible early repolarisation
T Wave
……. T wave changes are non specific
ECGs with the following statements should be faxed urgently to Glasgow
- Acute myocardial infarction
- Ventricular tachycardia
- AV dissociation
- Bradycardia < 40/minute
- Atrial Fibrillation with rapid ventricular response (>=120)

a) We do not wish to stop the sending of faxes. We are only suggesting how to minimise the number of faxes sent.

b) The guidelines list specifically states that, if these are the **ONLY** statements on an ECG, then there is no need to send it to us.

c) If a participant is complaining of chest pain, he/she should be advised to consult with his/her GP **IRRESPECTIVE** of the ECG interpretation.

d) With respect to an emergency, the nurses should send the ECG to Glasgow for urgent review. The ECG will be reviewed immediately and the result relayed to the respective centre by telephone and/or fax.

University of Glasgow

APPENDIX C

ADDENDUM B

CREATING AND MANAGING DATA QUERY PASSWORD PROTECTED DOCUMENTS:

When managing a Data Query in a study which involves documenting participant demographics, i.e. 'sensitive' data, the request for participant information must be noted in a password protected Word document as an attachment to an email and sent to the study centre or to the Clinical Trials Manager at the ECG core lab in Glasgow. The agreed password remains the same for the ECG core lab and UCL when sending or replying to a data query raised by either group.

Creating a protected Word document to send to the ECG core lab:

Create a Word document Data Query Folder to contain all data query documents
Create a new Word document for each query and enter the details of the query with full patient demographics as required
Save the document to the Data Query Folder using a study specific ID if possible, e.g. Hs123456
Select Tools tab
Select Options tab (bottom of the list)
Select the Security tab

- There is a section where it asks for the Password to be entered, which would allow the recipient to view the document – Enter agreed password
- There is a second section where it asks for the Password to be entered again, which will allow the 'sharing option', i.e. the recipient can also open and edit the document – Enter agreed password
- You will be asked to Enter the password again twice to CONFIRM the password
- Word document is now password protected and if all the required information has been entered in the Word document – Close document

Create Email and a short message re the data query but do not enter any participant demographic details. If possible, enter a relevant word or the data query ID number, e.g. Hs123456 into the email subject heading which will help to relate the data query to the protected Word document
Attach the protected Word document to the email and Send as normal to the Clinical Trials Manager

The Clinical Trials Manager can open the Word document only by entering the agreed password twice.

Handling a data query sent from the ECG Core Lab:

A data query sent from the ECG core lab in Glasgow will have been attached to an email and the subject heading will contain the data query ID number, e.g. DQ1800

Open the attached Word document
Enter the agreed password twice to view the Word document and to be able to edit and enter the answer to the query
Save the query to your Word document Data Query Folder
Open the query (again the password will be required)
Enter the requested information
Save the file
Password protect it as noted above
Send by email as an attachment as noted above

SETUP REPORT Page 1/2
17.06.2010 15:13:35

Setup:System
User 1-2 Select: 1
Date Format: DD.MM.YYYY
Date: 17.06.2010
Time: 15:13:35
Language: English
Height Units: IN.
Weight Units: LB.
Inst. Name: BRH Study
Paper Type: Assurance
Paper Size: A4 (8.27 x 11.69)
Administrative Password: OFF
Directory Password: OFF
AC Mains Frequency: 50 Hz
Battery Saver Mode: ON
Battery Saver Timeout(secs): 900
Waveform Grid: ON
Keypad Revision: Revision 2
Adjust Backlight:

Setup:Patient
Last Name: ON
First Name: ON
Date of Birth: ON
Age: ON
Age Format: ON
Gender: ON
Race: OFF
Medication 1: ON
Medication 2: ON
Class 1: ON
Class 2: ON
Height: OFF
Weight: OFF
Systolic BP: OFF
Diastolic BP: OFF
Department: OFF
Room: OFF
Technician: OFF
Physician: OFF
User Field: OFF
V3 Placement: OFF
Comment: ON

Setup:Waveform Preferences
Speed: 25 mm/s
Gain: 10 mm/mV
Artifact Filter: 40 Hz
Baseline Filter: STABLE Baseline
Line Filter: ON
Pacer Enhancement: ON
Lead Group: Custom 1

Setup:ECG:Report Format
12 Lead Format: STANDARD 4 CHANNEL
Rhythm Lead Ch.1: LEAD II
Print Rhythm Page: OFF
Print Median Complex Page: OFF
Number Of Copies: 0

Setup:ECG:Sequence
Wait for Good Data: ON
Auto Print: ON
Auto Save: Prompt
Auto Send: OFF

Setup:ECG:Interpretation Preferences
Analysis Statements: BRIEF
Print Interpretation on Original: ON
Print Interpretation on Copies: OFF
Bradycardia Limit: 60
Tachycardia Limit: 100
QTc Formula: Hodges

Setup:Custom 1
Custom 1: STANDARD LIMB 6-CHANNEL

Setup:Custom 2
Custom 2: STANDARD 12-CHANNEL

Setup:Printhead Resistance
Printhead Resistance: 1175

Setup:Directory
View Directory: View By Id

Setup:Auto Rhythm
Auto Rhythm Pages: 1

APPENDIX C

APPENDIX C

Setup:Send Receive:Network Connection
Network Type: Disabled

Setup:Send Receive:EMR Connection
Connection: Modem
EMR Description: GRI Connection
EMR Phone #: 901415528009
Phone Type: TOUCH TONE
Institution Number: 21
Device Id: 5191

Setup:Send Receive:Fax
Fax: Disabled

Setup:Send Receive:Email
Email: Disabled

Setup:Printer
Plain Paper Printing: OFF

Features Menu
Analysis Feature: ON
Measurements Feature: ON
Storage 150 Feature : OFF
Storage 300 Feature : OFF
Bluetooth Feature: OFF
802.11 Feature: ON
Communications Feature: ON

Option Key #1(G9YL-EEQML-G22P):
. Analysis:
. Measurements:
. 802.11:
. Communications:

The Minnesota Code Classification System† for Electrocardiographic Findings

Q and QS Patterns

(Do not code in the presence of WPW code 6-4-1.) To qualify as a Q- or QS-wave, the deflection should be at least 0.1 mV (1 mm in amplitude).

Anterolateral site (leads I, aVL, V_6)

1-1-1 Q/R amplitude ratio ≥ 1/3, plus Q duration ≥ 0.03 sec in lead I or V_6.

1-1-2 Q duration ≥ 0.04 sec in lead I or V_6.

1-1-3 Q duration ≥ 0.04 sec, plus R amplitude ≥ 3 mm in lead aVL.

1-2-1 Q/R amplitude ratio ≥ 1/3, plus Q duration ≥ 0.02 sec and < 0.03 sec in lead I or V_6.

1-2-2 Q duration ≥ 0.03 sec and < 0.04 sec in lead I or V_6.

1-2-3 QS pattern in lead I. Do not code in the presence of 7-1-1.

1-2-8 Initial R amplitude decreasing to 2 mm or less in every beat (and absence of codes 3-2, 7-1-1, 7-2-1, or 7-3 between V_5 and V_6. (All beats in lead V_5 must have an initial R > 2 mm.)

1-3-1 Q/R amplitude ratio ≥ 1/5 and < 1/3, plus Q duration ≥ 0.02 sec and < 0.03 sec in lead I or V_6.

1-3-3 Q duration ≥ 0.03 sec and < 0.04 sec, plus R amplitude ≥ 3 mm in lead aVL.

Posterior (inferior) site (leads II, III, aVF)

1-1-1 Q/R amplitude ratio ≥ 1/3, plus Q duration ≥ 0.03 sec in lead II.

1-1-2 Q duration ≥ 0.04 sec in lead II.

1-1-4 Q duration ≥ 0.05 sec in lead III, plus a Q-wave amplitude ≥ 1.0 mm in the majority of beats in lead aVF.

1-1-5 Q duration ≥ 0.05 sec in lead aVF.

1-2-1 Q/R amplitude ratio ≥ 1/3, plus Q duration ≥ 0.02 sec and < 0.03 sec in lead II.

1-2-2 Q duration ≥ 0.03 sec and < 0.04 sec in lead II.

1-2-3 QS pattern in lead II. Do not code in the presence of 7-1-1.

1-2-4 Q duration ≥ 0.04 sec and < 0.05 sec in lead III, plus a Q-wave ≥ 1.0 mm amplitude in the majority of beats in aVF.

1-2-5 Q duration ≥ 0.04 sec and < 0.05 sec in lead aVF.

1-2-6 Q amplitude ≥ 5.0 mm in leads III or aVF.

1-3-1 Q/R amplitude ratio ≥ 1/5 and < 1/3, plus Q duration ≥ 0.02 sec and < 0.03 sec in lead II.

1-3-4 Q duration ≥ 0.03 sec and < 0.04 sec in lead III, plus a Q-wave ≥ 1.0 mm amplitude in the majority of beats in lead aVF.

1-3-5 Q duration ≥ 0.03 sec and < 0.04 sec in lead aVF.

1-3-6 QS pattern in each of leads III and aVF. (Do not code in the presence of 7-1-1.)

Anterior site (leads V_1, V_2, V_3, V_4, V_5)

1-1-1 Q/R amplitude ratio ≥ 1/3 plus Q duration ≥ 0.03 sec in any of leads V_2, V_3, V_4, V_5.

1-1-2 Q duration ≥ 0.04 sec in any of leads V_1, V_2, V_3, V_4, V_5.

1-1-6 QS pattern when initial R-wave is present in adjacent lead to the right on the chest, in any of leads V_2, V_3, V_4,V_5, V_6.

1-1-7 QS pattern in all of leads V_1-V_4 or V_1-V_5.

1-2-1 Q/R amplitude ratio ≥ 1/3, plus Q duration ≥ 0.02 sec and < 0.03 sec, in any of leads V_2, V_3, V_4, V_5.

1-2-2 Q duration ≥ 0.03 sec and < 0.04 sec in any of leads V_2, V_3, V_4, V_5.

1-2-7 QS pattern in all of leads V_1, V_2, and V_3. (Do not code in the presence of 7-1-1).

1-2-8 Initial R amplitude decreasing to 2.0 mm or less in every beat (and absence of codes 3-2, 7-1-1, 7-2-1, or 7-3) between any of leads V_2 and V_3, V_3 and V_4, or V_4 and V_5. (All beats in the lead immediately to the right on the chest must have an initial R > 2 mm.)

1-3-1 Q/R amplitude ratio ≥ 1/5 and < 1/3 plus Q duration ≥ 0.02 and < 0.03 sec in any of leads V_2, V_3, V_4, V_5.

1-3-2 QS pattern in lead V_1 and V_2. (Do not code in the presence of 3-1 or 7-1-1.)

QRS Axis Deviation

(Do not code in presence of low-voltage QRS, code 9-1, WPW 6-4-1, ventricular conduction defects, or 7-1-1, 7-2-1, and 7-4.)

2-1 Left. QRS axis from -30^0 through -90^0 in leads I, II, III. (The algebraic sum of major positive and major negative QRS waves must be zero or positive in I, negative in III, and zero or negative in II.)

2-2 Right. QRS axis from $+120^0$ through -150^0 in leads I, II, III. (The algebraic sum of major positive and major negative QRS waves must be negative in I, and zero or positive in III, and in I must be one-half or more of that in III.)

2-3 Right (optional code when 2-2 is not present). QRS axis from $+90^0$ through $+119^0$ in leads I, II, III. (The algebraic sum of major positive and major negative QRS waves must be zero or negative in I and positive in II and III.)

2-4 Extreme axis deviation (usually S1, S2, S3 pattern). QRS axis from -90^0 through -149^0 in leads I, II, and III (The algebraic sum of major positive and major negative QRS waves must be negative in each of leads I, II, and III.)

2-5 Indeterminate axis QRS axis approximately 90^0 from the frontal plane. (The algebraic sum of major positive and major negative QRS waves is zero in each of leads I, II and III, or the information from these three leads is incongruous.)

High Amplitude R Waves

3-1 Left: R amplitude > 26 mm in either V_5 or V_6, or R amplitude > 20.0 mm in any of leads I, II, III, aVF, or R amplitude > 12.0 mm in lead aVL. (All criteria measured only on second to last complete normal beat.)

3-2 Right: R amplitude ≥ 5.0 mm and R amplitude ≥ S amplitude in the majority of beats in lead V_1, when S amplitude is > R amplitude somewhere to the left on the chest of V_1 (codes 7-3 and 3-2, if criteria for both are present).

3-3 Left (optional code when 3-1 is not present): R amplitude > 15.0 mm but ≤ 20.0 mm in lead I, or R amplitude in V_5 or V_6, plus S amplitude in V_1 > 35.0 mm. (Measured only on second to last complete normal beat.)

3-4 Criteria for 3-1 and 3-2 both present.

ST Junction (J) and Segment Depression

(Do not code in the presence of codes 6-4-1, 7-1-1, 7-2-1 or 7-4. When 4-1, 4-2, or 4-3 is coded, then a 5-code must also be assigned except in lead V_1.)

Anterolateral site (leads I, aVL, V_6)

4-1-1 STJ depression ≥ 2.0 mm and ST segment horizontal or downward sloping in any of leads I, aVL, or V_6.

4-1-2 STJ depression ≥ 1.0 mm but < 2.0 mm, and ST segment horizontal or downward sloping in any of leads I, aVL, or V_6.

4-2 STJ depression ≥ 0.5 mm and < 1.0 mm and ST segment horizontal or downward sloping in any of leads I, aVL, or V_6.

4-3 No STJ depression as much as 0.5 mm but ST segment downward sloping and segment or T-wave nadir ≥ 0.5 mm below P-R baseline, in any of leads I, aVL, or V_6.

4-4 STJ depression ≥ 1.0 mm and ST segment upward sloping or U-shaped, in any of leads I, aVL, or V_6.

Posterior (inferior) site (leads II, III, aVF)

4-1-1 STJ depression ≥ 2.0 mm and ST segment horizontal or downward sloping in lead II or aVF.

4-1-2 STJ depression ≥ 1.0 mm but < 2.0 mm and ST segment horizontal or downward sloping in lead II or aVF.

4-2 STJ depression ≥ 0.5 mm and < 1.0 mm and ST segment horizontal or downward sloping in lead II or aVF.

4-3 No STJ depression as much as 0.5 mm, but ST segment downward sloping and segment or T-wave nadir ≥ 0.5 mm below P-R baseline in lead II.

4-4 STJ depression ≥ 1.0 mm and ST segment upward sloping, or U-shaped, in lead II.

ST Junction (J) and Segment Depression (continued)

Anterior site (leads V_1, V_2, V_3, V_4, V_5)

4-1-1 STJ depression ≥ 2.0 and ST segment horizontal or downward sloping in any of leads V_1, V_2, V_3, V_4, V_5.

4-1-2 STJ depression ≥ 1.0 mm but < 2.0 mm and ST segment horizontal or downward sloping in any of leads V_1, V_2, V_3, V_4, V_5

4-2 STJ depression ≥ 0.5 mm and < 1.0 mm and ST segment horizontal or downward sloping in any of leads V_1, V_2, V_3, V_4, V_5.

4-2 No STJ depression as much as 0.5 mm, but ST segment downward sloping and segment or T-wave nadir ≥ 0.5 mm below P-R baseline in any of leads V_2, V_3, V_4, V_5.

4-4 STJ depression ≥ 1.0 mm and ST segment upward sloping or U-shaped in any of leads V_1, V_2, V_3, V_4, V_5.

T-Wave Items

(Do not code in the presence of code 6-4-1, 7-1-1, 7-2-1 or 7-4.)

Anterolateral site (leads I, aVL, V_6)

5-1 T amplitude negative 5.0 mm or more in either of leads I, V_6, or in lead aVL when R amplitude is ≥ 5.0 mm.

5-2 T amplitude negative or diphasic (positive-negative or negative-positive type) with negative phase at least 1.0 mm but not as deep as 5.0 mm in lead I or V_6, or in lead aVL when R amplitude is ≥ 5.0 mm.

5-3 T amplitude zero (flat), or negative, or diphasic (negative-positive type only) with less than 1.0 mm negative phase in lead I or V_6, or in lead aVL when R amplitude is ≥ 5.0 mm.

5-4 T amplitude positive and T/R amplitude ratio < 1/20 in any of leads I, aVL, V_6; R wave amplitude must be ≥ 10.0 mm.

Posterior (inferior) site (leads II, III, aVF)

5-1 T amplitude negative 5.0 mm or more in lead II, or in lead aVF when QRS is mainly upright.

5-2 T amplitude negative or diphasic with negative phase (negative-positive or positive-negative type) at least 1.0 mm but not as deep as 5.0 mm in lead II, or in lead aVF when QRS is mainly upright.

5-3 T amplitude zero (flat), or negative, or diphasic (negative-positive type only) with less than 1.0 mm negative phase in lead II; not coded in lead aVF.

5-4 T amplitude positive and T/R amplitude ratio < 1/20 in lead II; R wave amplitude must be ≥ 10.0 mm.

Anterior site (leads V_2, V_3, V_4, V_5)

5-1 T amplitude negative 5.0 mm or more in any of leads V_2, V_3, V_4, V_5.

5-2 T amplitude negative (flat), or diphasic (negative-positive or positive-negative type) with negative phase at least 1.0 mm but not as deep as 5.0 mm, in any of leads V_2, V_3, V_4, V_5.

5-3 T amplitude zero (flat), or negative, or diphasic (negative-positive type only) with less than 1.0 mm negative phase, in any of leads V_3, V_4, V_5.

5-4 T amplitude positive and T/R amplitude ratio < 1/20 in any of leads V_3, V_4, V_5; R wave amplitude must be ≥ 10.0 mm.

A-V Conduction Defect

6-1 Complete (third degree) A-V block (permanent or intermittent) in any lead. Atrial and ventricular complexes independent, and atrial rate faster than ventricular rate, with ventricular rate < 60.

6-2-1 Mobitz Type II (occurrence of P-wave on time with dropped QRS and T).

6-2-2 Partial (second degree) A-V block in any lead (2:1 or 3:1 block).

6-2-3 Wenckebach's Phenomenon (P-R interval increasing from beat to beat until QRS and T dropped).

6-3 P-R (P-Q) interval ≥ 0.22 sec in the majority of beats in any of leads I, II, III, aVL, aVF.

6-4-1 Wolff-Parkinson-White Pattern (WPW), persistent. Sinus P-wave. P-R interval < 0.12 sec, plus QRS duration ≥ 0.12 sec, plus R peak duration ≥ 0.06 sec, coexisting in the same beat and present in the majority of beats in any of leads I, II, aVL, V_4, V_5, V_6. (6-4-1 suppresses 1-2-3, 1-2-7, 1-2-8, 1-3-2, 1-3-6, all 3, 4, 5, 9-2, 9-4, 9-5 codes.)

6-4-2 WPW Pattern, intermittent. WPW pattern in ≤ 50% of beats in appropriate leads.

6-5 Short P-R interval. P-R interval < 0.12 sec in all beats of any two of leads I, II, III, aVL, aVF.

6-6 Intermittent aberrant atrioventricular conduction. P-R > 0.12 sec (except in presence of 6-5 or heart rate greater than 100); wide QRS complex > 0.12 sec; normal P-wave when most beats are sinus rhythm. (Do not code in the presence of 6-4-2.)

6-8 Artificial pacemaker.

Ventricular Conduction Defect

7-1-1 Complete left bundle branch block (LBBB). (Do not code in presence of 6-1, 6-4-1, 6-8, 8-2-1 or 8-2-2.) QRS duration ≥ 0.12 sec in a majority of beats in any of leads I, II, III, aVL, aVF, *plus* R peak duration ≥ 0.06 sec in a majority of beats (of the same QRS pattern) in any of leads I, II, aVL, V_5, V_6. (7-1-1 suppresses 1-2-3, 1-2-7, 1-2-8, 1-3-2, 1-3-6, all 2, 3, 4, 5, 9-2, 9-4, 9-5 codes. If any other codable Q-wave coexists with the LBBB pattern, code the Q and diminish the 7-1-1 code to a 7-4 code.)

7-1-2 Intermittent left bundle branch block. Same as 7-1-1 but with presence of normally conducted QRS complexes of different shape than the LBBB pattern.

7-2-1 Complete right bundle branch block (RBBB). (Do not code in the presence of 6-1, 6-4-1, 6-8, 8-2-1 or 8-2-2.) QRS duration ≥ 0.12 sec in a majority of beats in any of leads I, II, III, aVL, aVF, *plus*: R' > R in V_1 or V_2; or QRS mainly upright, with R peak duration ≥ 0.06 sec in V_1 or V_2; or S duration >R duration in all beats in lead I or II. (7-1 suppresses 1-2-3, 1-2-7, 1-2-8, 1-3-2, 1-3-6, all 2, 3, 4, 5, 9-2, 9-4, 9-5 codes.

7-2-2 Intermittent right bundle branch block. Same as 7-2-1 but with presence of normally conducted QRS complexes of different shape than the RBBB pattern.

7-3 Incomplete right bundle branch block. QRS duration < 0.12 sec in each of leads I, II, III, aVL, aVF, and R' > R in either of leads V_1, V_2 .(Code as 3-2 in addition if those criteria are met. 7-3 suppresses code 1-2-8.)

7-4 Intraventricular block. QRS duration ≥ 0.12 sec in a majority of beats in any of leads I, II, III, aVL, aVF. (7-4 suppresses all 2, 3, 4, 5, 9-2, 9-4, 9-5 codes.)

7-5 R-R' pattern in either of leads V_1, V_2 with R' amplitude ≥ R.

7-6 Incomplete left bundle branch block. (Do not code in the presence of any codable Q- or QS-wave.) QRS duration ≥ 0.10 sec and < 0.12 in the majority of beats of each of leads I, aVL, and V_5 or V_6.

7-7 Left anterior hemiblock (LAH). QRS duration < 0.12 sec in the majority of beats in leads I, II, III, aVL, aVF, plus Q-wave amplitude ≥ 0.25 mm and < 0.03 sec duration in lead I, plus left axis deviation of -45^0 or more negative. (In presence of 7-2, code 7-8 if axis is < -45^0 and the Q-wave in lead I meets the above criteria.)

7-8 Combination of 7-7 and 7-2.

Arrhythmias

8-1-1 Presence of frequent atrial or junctional premature beats (10% or more of recorded complexes).
8-1-2 Presence of frequent ventricular premature beats (10% or more of record complexes).
8-1-3 Presence of both atrial and/or junctional premature beats and ventricular premature beats (so that individual frequencies are < 10% but *combined* premature beats are ≥ 10% of complexes).
8-1-4 Wandering atrial pacemaker.
8-1-5 Presence of 8-1-2 and 8-1-4.
8-2-1 Ventricular fibrillation or ventricular asystole.
8-2-2 Persistent ventricular (idioventricular) rhythm.
8-2-3 Intermittent ventricular tachycardia. Three or more consecutive ventricular premature beats occurring at a rate ≥100. This includes more persistent ventricular tachycardia.
8-2-4 Ventricular parasystole (should not be coded in presence of 8-3-1).
8-3-1 Atrial fibrillation (persistent).
8-3-2 Atrial flutter (persistent).
8-3-3 Intermittent atrial fibrillation (code if 3 or more clear-cut, consecutive sinus beats are present in any lead).
8-3-4 Intermittent atrial flutter (code of 3 or more clear-cut, consecutive sinus beats are present in any lead).
8-4-1 Supraventricular rhythm persistent. QRS duration < 0.12 sec; and absent P-waves or presence of abnormal P-waves (inverted or flat in aVF); and regular rhythm.
8-4-2 Supraventricular tachycardia intermittent. Three consecutive atrial or junctional premature beats occurring at a rate ≥ 100.
8-5-1 Sinoatrial arrest. Unexpected absence of P, QRS and T, plus a R-R interval at a fixed multiple of he normal interval, ± 10%.
8-5-2 Sinoatrial block. Unexpected absence of P, QRS and T, preceded by progressive shortening of P-P intervals. (R-R interval at a fixed multiple of the normal interval, ± 10%.
8-6-1 A-V dissociation with ventricular pacemaker (without capture). Requires: P-P and R-R occur at variable rates with ventricular rate as fast as or faster than the atrial rate, plus variable P-R intervals, plus no capture beats.
8-6-2 A-V dissociation with ventricular pacemaker (with capture).
8-6-3 A-V dissociation with atrial pacemaker (without capture).
8-6-4 A-V dissociation with atrial pacemaker (with capture).
8-7 Sinus tachycardia (over 100/min).
8-8 Sinus bradycardia (under 50/min).
8-9 Other arrhythmias. Heart rate may be recorded as a continuous variable.

ST Segment Elevation

Anterolateral site (leads I, aVL, V_6)

9-2 ST segment elevation ≥ 1.0 mm in any of leads I, aVL, V_6.

Posterior (inferior) site (leads II, III, aVF)

9-2 ST segment elevation ≥ 1.0 mm in any of leads II, III, aVF.

Anterior site (leads V_1, V_2, V_3, V_4, V_5)

9-2 ST segment elevation ≥ 1.0 mm in lead V5 or ST segment elevation ≥ 2.0 mm in any of leads V_1, V_2, V_3, V_4.

Miscellaneous Items

9-1 Low QRS amplitude. QRS peak-to-peak amplitude < 5 mm in all beats in each of leads I, II, III, or < 10 mm in all beats in each of leads V_1, V_2, V_3, V_4, V_5, V_6. (Check calibration before coding.)

9-3 P-wave amplitude ≥ 2.5 mm in any of leads II, III, aVF, in a majority of beats.

9-4-1 QRS transition zone at V_3 or to the right of V_3 on the chest. (Do not code in the presence of 6-4-1, 7-1-1, 7-2-1 or 7-4.)

9-4-2 QRS transition zone at V_4 or to the left of V_4 on the chest. (Do not code in the presence of 6-4-1, 7-1-1, 7-2-1 or 7-4.)

9-5 T-wave amplitude > 12 mm in any of leads I, II, III, aVL, aVF, V_1, V_2, V_3, V_4, V_5, V_6. (Do not code in the presence of 6-4-1, 7-1-1, 7-2-1 or 7-4.)

9-8-1 Technical problems which interfere with coding.

9-8-2 Technical problems which do not interfere with coding.

Incompatible Codes

The codes in the left column suppress codes in the right column.

Code	Suppress this code(s)
All Q-, QS-codes	7-6
Q > 0.03 in lead I	7-7
3-1	1-3-2
3-2	1-2-8, 7-3
6-1	All other codes except 8-2
6-4-1	All other codes
6-8	All other codes
7-1-1	1-2-3, 1-2-7, 1-2-8, 1-3-2, 1-3-6, all 2-, 3-, 4-, and 5- codes, 7-7, 9-2, 9-4, 9-5
7-2-1	1-2-8, all 2-, 3-, 4-, and 5-codes, 9-2, 9-4, 9-5
7-3	1-2-8
7-4	All 2-, 3-, 4-, and 5-codes, 9-2, 9-4, 9-5
8-1-2	8-2-4
8-1-4	8-1-1, 9-3
8-2-1	All other codes
8-2-2	All other codes
8-2-3	8-1-2
8-3-1	8-1-1, 8-1-2
8-3-2	6-2-2, 8-1-1, 8-1-2
8-3-3	8-1-1, 8-1-2
8-3-4	6-2-2
8-4-1	6-5
8-4-1 + heart rate ≥ 140	All other codes except 7-4 or 6-2
Heart rate > 100	6-5
8-4-2	8-1-1
9-1 All 2-codes	

Categories of Minnesota ECG Abnormalities

Diagnostic ECG:
(any ECG may be used for this classification)

D1. An ECG record with any Diagnostic Q-code (Minn. code 1-1-1 through 1-2-5 plus 1-2-7).

D2. An ECG record with ST-segment elevation code 9-2 PLUS (T-wave inversion code 5-1 or 5-2 in the absence of 7-2-1 or 7-4).

Equivocal ECG:
(any ECG may be used for this classification)

E1. An ECG record with an Equivocal Q-code [(Minn. code 1-2-8 in the absence of a 7-1-1 or 7-3 or (any 1-3-code)].

E2. An ECG record with ST-segment depression (code 4-1-x or 4-2 or 4-3 in the absence of 7-2-1 or 7-4), or 1-3-x.

E3. An ECG record with T-wave inversion (code 5-1 or 5-2 or 5-3 in the absence of 7-2-1 or 7-4).

E4. An ECG record with ST-segment elevation code 9-2.

Other ECG:

01. Reference ECG coded 7-1-1.

02. Any ECG coded 7-1-1.

03. Normal ECG(s), defined as 1 in "clear" field of all ECGs.

04. Other findings including 1-2-6.

Uncodable ECG:

U1. Technical errors coded 9-8-1 by Minnesota Code.

Absent ECG:

A1. No ECG available for coding.

† Prineas R, Crow R, Blackburn H. The Minnesota Code Manual of Electrocardiographic Findings. John Wright-PSG, Inc. Littleton, MA, June 1982.