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Understanding the ECG. Part 6: QRS axis

Introduction

Electrical activity in the heart is created by the depolarisation of individual myocytes (Klabunde, 2012). The electrical impulse created sweeps through the atria before passing into the specialised conduction system, and entering the ventricles, where it is distributed to both chambers in a rapid and efficient manner (Pappano and Wier, 2013). We tend to think of this process as being linear, and two dimensional, because this is how it is depicted in textbooks. In reality, the heart is a three dimensional structure, and waves of depolarisation are moving in many directions simultaneously as electrical activity spreads through the walls of the heart (Garcia, 2015). An electrical axis is the net direction in which depolarising waves are moving, in other words the predominant direction when all the waveforms are added together (Davies, 2007). Electrical axis can be calculated for all the waveforms and intervals on the 12-lead ECG, however the most important is the QRS axis, representing the net direction of depolarisation within the ventricles (Hampton, 2013).

The QRS axis provides important diagnostic information about the flow of electricity through the ventricles, and is useful in diagnosing abnormalities in both the structure and electrical function of the heart (Garcia, 2015). Despite its usefulness, it is often considered a difficult subject in ECG interpretation, and one that students struggle to grasp (Davies, 2007; Houghton and Gray, 2014). This difficulty may be compounded by a plethora of methods suggested for axis evaluation, and by a lack of conformity in the literature about where the normal axis lies, and what causes it to be abnormal.

In this sixth article of the *British Journal of Cardiac Nursing* ECG Interpretation series, we hope to shed some light on these issues, and to describe the QRS axis in terms that readers can understand. We will present the currently accepted definitions of both normal and abnormal axis, as defined by internationally agreed practice guidelines. We will also explain how to evaluate axis on the 12-lead ECG, using simple methods that are appropriate to the clinical setting. Finally, we will examine the most common cause of axis deviation, the fascicular blocks.
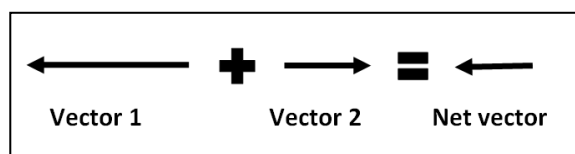
Vectors

To understand electrical axis, it's useful to start with the concept of vectors. A vector is a mathematical concept used to describe a force that has both direction and magnitude (Garcia, 2015). Vectors are usually represented by arrows - with the length of the arrow representing magnitude, and the direction of the arrow the direction that the force is moving in (Aehlert, 2011). Imagine firing a plastic dart from a child's toy gun. The force propelling the dart can be described as a vector – it has direction and magnitude. Now imagine firing a real gun in the same direction. Again there is a vector, but in this case the magnitude is much greater. These two vectors could be represented by two arrows, one short and one long, as shown in *figure 1*.

In many situations, the forces acting on objects move in different directions (Shankar, 2014). If you've ever watched a tug-of-war, you will have seen two opposing vectors. The two teams are pulling in opposite directions, and whichever is strongest defines the direction that the rope travels in *(figure 2)*. If the two teams (vectors) are of equal strength (magnitude), they cancel each other out, and the rope remains static. The same principles apply to waves of depolarisation in the heart, which can also be described in terms of vectors (Garcia, 2015). During ventricular depolarisation, these vectors are moving in many directions, for example through the anterior and posterior walls of both the right and left ventricles. If we add all of these vectors together, the net direction is the QRS axis (Kuhn and Rose, 2008). In adults, this travels downwards and towards the left as shown in *figure 3*. This is because the vectors produced by the thicker walled left ventricle outweigh those produced by the right (Aehlert, 2011).
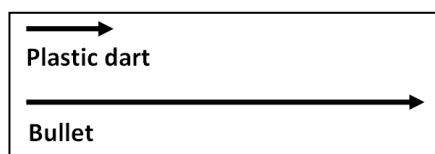
Figure 1. The arrow representing the bullet is longer because the force driving it has much greater magnitude than the plastic dart.

Figure 2. Both teams are pulling hard, but the team pulling to the left (vector 1) is stronger (has greater magnitude). When the two vectors are added, the result is a small vector moving to the left.
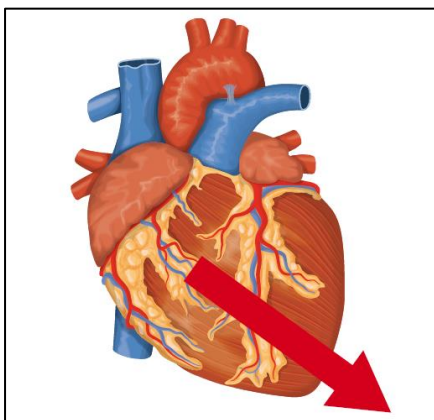

Figure 3. The normal QRS axis in adults is downward and towards the left.

Defining normal QRS axis

QRS axis refers to ventricular depolarisation as seen in a frontal plane, in other words from the perspective of the limb leads (Houghton and Gray, 2014). It is therefore these leads that are used to evaluate it. Some authors describe QRS axis as the "mean frontal QRS axis", which makes this more explicit (Davies, 2007).

To evaluate QRS axis, the limb leads are placed in the hexaxial reference system (Burns, 2014) *(figure 4)*. This system places the limb leads in a circle surrounding the heart, according to their electrical viewpoint. The position of each lead is measured in degrees, relative to lead I, which is at zero degrees (Hampton, 2013). Leads in the lower half of the circle are calculated in positive degrees moving clockwise from lead I, while leads in the upper half of the circle are measured in negative degrees, moving anticlockwise from the same starting position (Garcia, 2015).

In adults, a variety of ranges for normal QRS axis have been proposed, however the current standard is -30 to +90 degrees (Surawicz et al, 2009). An axis that falls outside of this range is referred to as axis deviation (Davies, 2007). Left axis deviation (LAD) is from -30 to -90 degrees, while right axis deviation (RAD) is from +90 to 180 degrees (Surawicz et al, 2009). Extreme axis deviation, from -90 to 180 degrees, is also referred to as "no-man's land" or a "northwest axis" (Burns, 2014; Davies, 2007). Rarely, it is not possible to determine the QRS axis, in which case it is described as "indeterminate" (Kilicaslan et al, 2007).
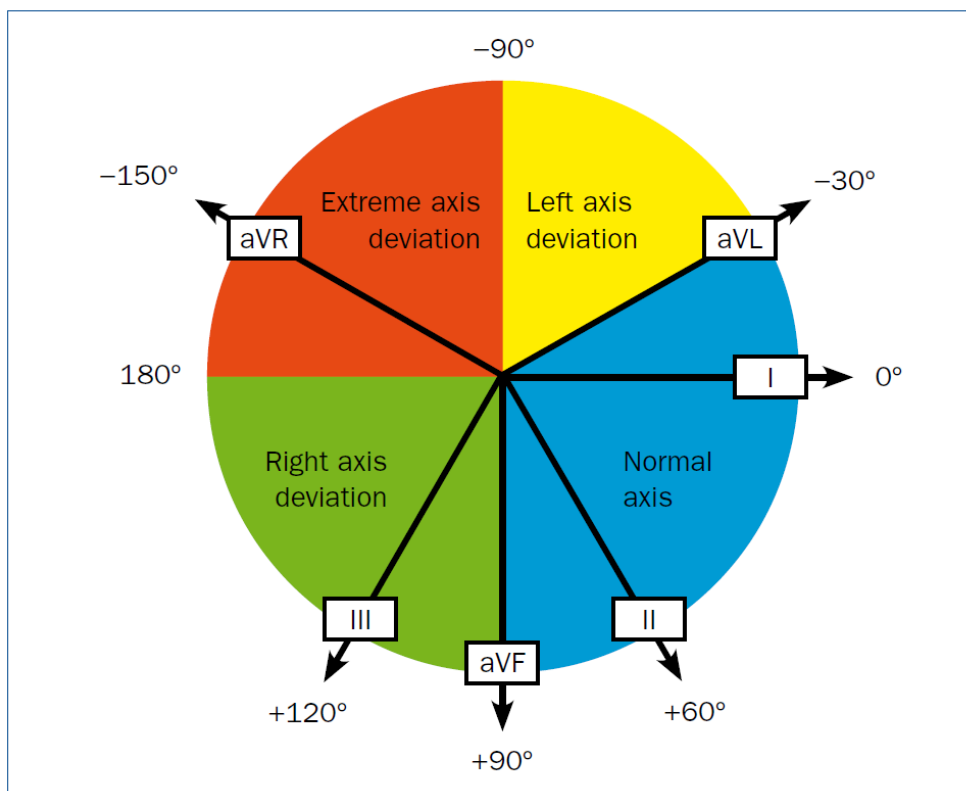
Figure 4. The hexaxial reference system. Note that the position of each limb lead is calculated according to its position relative to lead I, which is at zero degrees.

Axis deviation

The QRS axis is dependent on a number of factors including age and body shape, the size of the ventricles, the route taken by the electrical impulse, and the placement of the limb leads (Davies, 2007). This results in considerable variation in what is considered normal, as well as the potential for a range of abnormal findings (Burns, 2014).

In children, the QRS axis is further to the right, and moves leftward during growth to adulthood (Surawicz et al, 2009). A more rightward axis is also common in tall, thin individuals in whom the heart is orientated more vertically in the chest (Davies, 2007). RAD may be a normal variant in people with this body shape. In contrast, when the body is shorter and wider the heart may be tilted to a more horizontal position, resulting in a more leftward axis (Kuhn and Rose, 2008). Conditions that increase the size of the abdomen, for example ascites or pregnancy, may push the heart into a more horizontal position, resulting in LAD (Adamson and Nelson-Piercy, 2007; Goloba et al, 2010).

Alteration in the relative size of the ventricles also has the potential to alter QRS axis (Hampton, 2013). In left ventricular (LV) hypertrophy, thickening of the LV wall increases the magnitude of depolarising vectors moving towards the left (Hancock et al, 2009). This moves the mean QRS axis to the left, and can result in LAD. The same phenomenon is possible in the case of right ventricular enlargement, in which case the axis shifts to the right (Josephson, 2010). Loss of functioning muscle, for example due to myocardial infarction, can have the opposite effect, shifting the axis away from the damaged area of the heart (Kuhn and Rose, 2008).

Electrical activation of the ventricles has perhaps the greatest effect on QRS axis (Bennett, 2013). We know from our discussions of bundle branch blocks and pre-excitation that abnormalities in conduction can alter the pattern of depolarisation in the ventricles (Sampson, 2016a; Sampson, 2016b). These abnormalities can also alter the QRS axis, although Garcia (2015) suggests that this rarely occurs due to bundle branch block. In addition, there are two electrical abnormalities that result in marked axis deviation. The first is block in one fascicle of the left bundle branch (Burns, 2014). Fascicular blocks are a common and clinically important cause of axis deviation, and are discussed further below. The second is abnormal activation of the ventricles during ventricular arrhythmias (Garcia, 2015). Ventricular tachycardia (VT) can cause extreme axis deviation, which is otherwise rarely seen (Davies, 2007). Evaluation of QRS axis can therefore be useful in distinguishing between VT and supraventricular tachycardia with aberrant conduction (Bennett, 2013).

Finally, misplacement of the limb leads can radically alter the axis, and has the potential to cause misdiagnosis (Crawford and Doherty, 2008). Most commonly, the arm electrodes are transposed, resulting in an ECG that suggests right or extreme axis deviation (Harrigan et al, 2012). Careful evaluation of the ECG, however, will demonstrate other abnormal features such as inverted P-waves in lead I, and an upright QRS in aVR. It should be noted that similar changes are seen on the ECGs of people with dextrocardia (Uchenna et al, 2012). In this condition, however, the location of the heart in the right side of the chest also results in abnormal R wave progression. This is not seen in limb lead misplacement, which can be confirmed simply by repeating the ECG and ensuring the leads are placed on the correct limbs (Eldridge and Richley, 2014). *Table 1* lists the more commonly cited causes of right and left axis deviation (Aehlert, 2011; Burns, 2014; Davies, 2007; Garcia, 2015; Houghton and Gray, 2014; Kuhn and Rose, 2008).

Left axis deviation	Right axis deviation
Left anterior fascicular block	Left posterior fascicular block
Inferior myocardial infarction	Anterolateral myocardial infarction
Left ventricular hypertrophy	Right ventricular hypertrophy
Left bundle branch block	Right bundle branch block
Ventricular pacing	Pulmonary embolism
Pre-excitation	Pre-excitation
Ventricular arrhythmias	Ventricular arrhythmias
Pregnancy, ascites or abdominal tumour	Dextrocardia
Short, squat body shape	Tall, thin body shape
Hyperkalaemia	Normal in children and adolescents

*Table 1. Possible causes of axis deviation in adults.*

Evaluating QRS axis

Before we discuss evaluation of the QRS axis, we need to reiterate an important principle in ECG interpretation concerning the orientation of waveforms. This principle states that a wave of depolarisation moving towards an ECG lead creates a positive (upward) deflection, while one moving away creates a negative (downward) one (Garcia, 2015). We can add to this principle as follows:

- Many QRS complexes have both positive and negative components. This indicates that the depolarising wave is moving at an angle to the lead, rather than directly towards or away from it (Davies, 2007).

- When the positive part is larger than the negative part, the depolarising wave is moving more towards the lead than away from it. The QRS is described as positive (Hampton, 2013).

- The opposite applies if the negative part is larger (Hampton, 2013).

- If a QRS complex has positive and negative parts that are equal, the depolarising wave is moving at 90 degrees to the lead. The QRS complex is described as isoelectric, or equiphasic (Garcia, 2015).

These different ECG appearances are illustrated in *figure 5*.
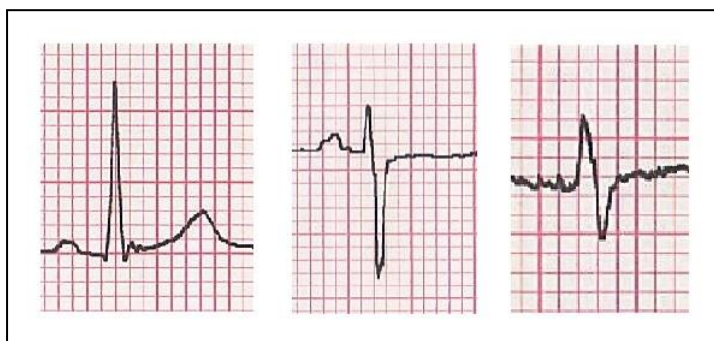
*Figure 5. Positive, negative, and isoelectric QRS complexes.*

So how does this help us with QRS axis? Axis cannot be measured directly so it must be inferred from the polarity of the QRS complexes in the limb leads (Davies, 2007). In other words, by comparing which leads are positive and which negative, we can use logic to work out where the axis lies. Most ECG machines perform this calculation, and display the QRS axis at the top of the print out (*figure 6*). In the vast majority of cases, this is the most accurate way of determining the axis (Spodick et al, 2009). ECG machines are not infallible, however, and some machines may not calculate the axis (Kuhn and Rose, 2008). Practitioners must therefore be able to calculate axis manually. This can be done using a quadrant based system, or by evaluating the most isoelectric limb lead (Garcia, 2015). Let's start with the quadrant approach.
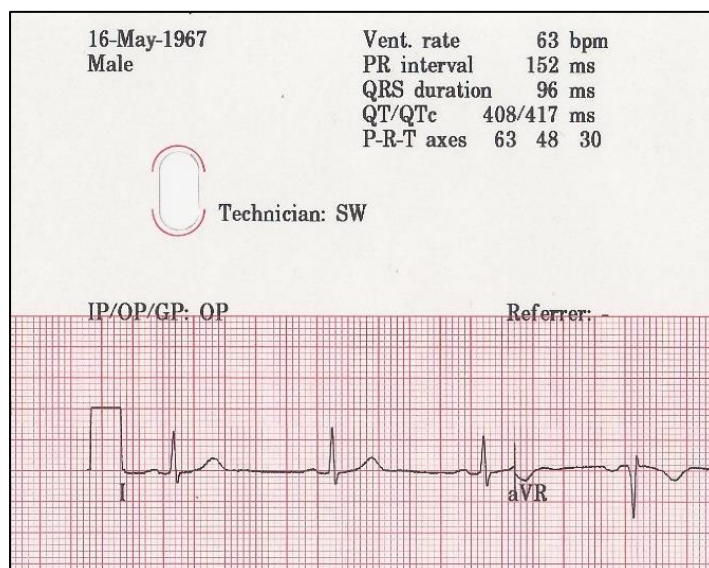
Figure 6. The top left corner of a typical 12-lead ECG. The machine's calculations can be seen at the top right, and include ventricular rate, PR interval and so on. At the bottom of the list is P-R-T axes. R is the QRS axis, which in this case is 48 degrees, and therefore normal.

Quadrant approach to axis determination

If we look at the hexaxial system, we can see that lead I sits at the horizontal axis of the system, and lead aVF at the vertical (Hampton, 2013). If we draw a line across from each of these leads, it divides the system into four quadrants (*figure 7*). By examining the QRS complex in leads I and aVF, and deciding if it is positive or negative, we can place the QRS axis in one of these quadrants. This is the first step in the quadrant approach (Garcia, 2015).
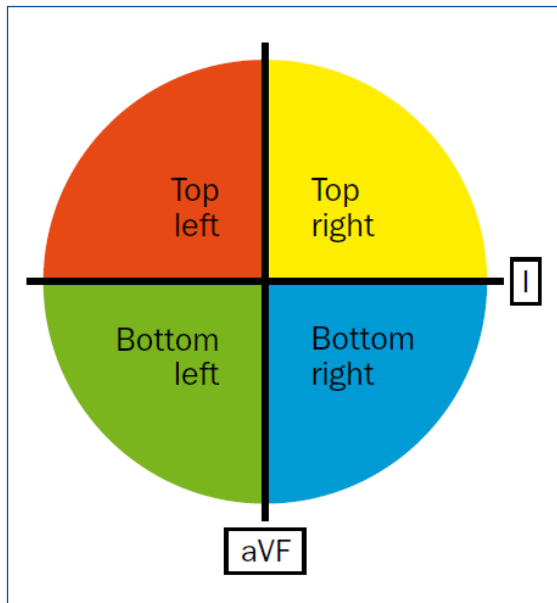
Figure 7. Leads I and aVF can be used to divide the hexaxial system into quadrants.

So, how does this work? Let's think about lead I, and go back to our first principles. Use *figure 4* to remind yourself about lead positions as we go along. A wave of depolarisation moving towards zero degrees will create an entirely upright QRS in lead I (Davies, 2007). Either side of zero, the QRS will still be more positive than negative (or isoelectric) if the axis is as far left as -90 degrees, or as far right as +90 degrees (Garcia, 2015). So, a positive QRS in lead I locates the axis in the right half of our hexaxial system, while a negative QRS places it in the left half (Garcia, 2015) (*figure 8*).
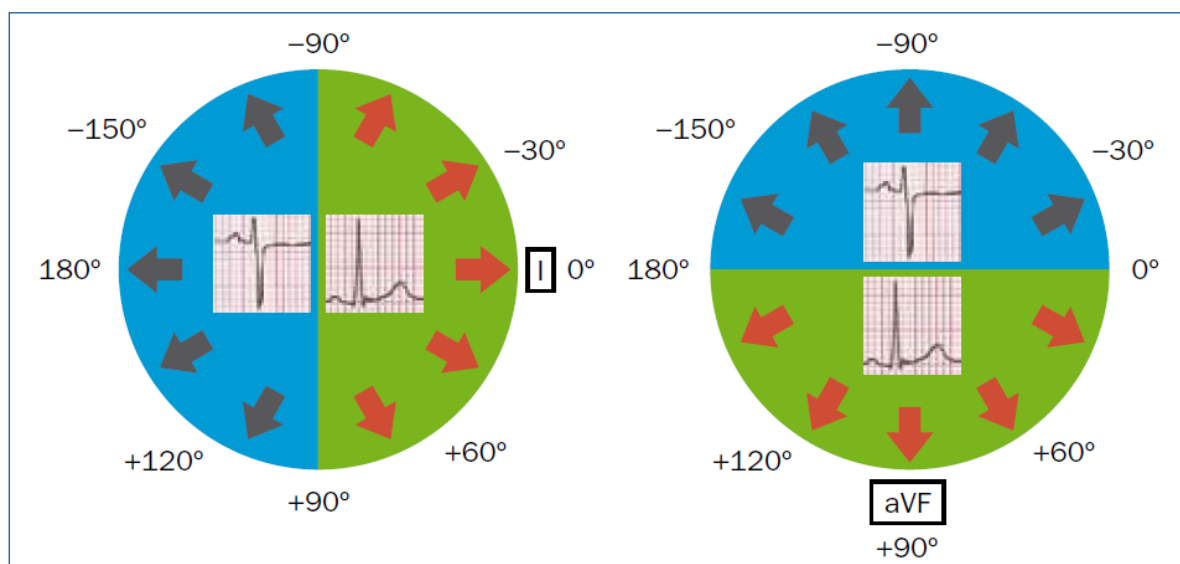
Figure 8. Red arrows indicate an axis moving towards the lead, grey arrows an axis moving away. When lead I is positive, the axis falls within the right half of the hexaxial system. When it is negative, the axis is in the left half. Lead aVF divides the system into upper and lower halves in the same way.

Next, let's think about lead aVF. If lead aVF is positive, the axis must be travelling towards +90 degrees, or within 90 degrees either side (Houghton and Gray, 2014) (*figure 8*). This locates the axis in the bottom half of our hexaxial system (Garcia, 2015). If aVF is negative, the axis must be in the top half.

As you can see, examination of these two leads effectively places the axis within one quadrant of the hexaxial system (*figure 9*). This is sufficient to determine both right axis deviation (QRS is positive in aVF but negative in lead I) and extreme axis deviation (both lead I and aVF are negative) (Davies, 2007). So how about a normal axis versus left axis deviation?
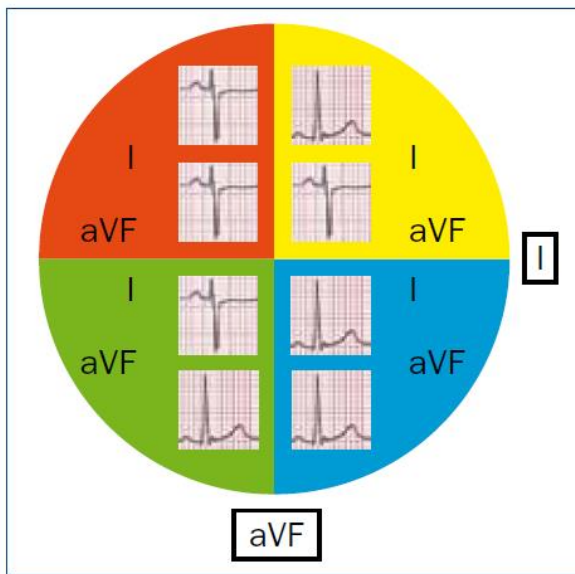

Figure 9. Using leads I and aVF, we can place the axis in one quadrant of the hexaxial system. This is enough to identify right and extreme axis deviation.

The difficulty here is that the normal axis occupies more than one quadrant (Garcia, 2015). If you look at *figure 4*, you can see that the normal axis is between -30 and +90 degrees (Surawicz et al, 2009). There is therefore a thin wedge of normal axis, between zero and -30 degrees, that lies in the upper right quadrant. If both lead I and aVF are positive, we know that the axis lies in the bottom right quadrant, and the axis is normal (Davies, 2007). But what about when lead I is positive, and aVF is negative? This places the axis in the top right quadrant, and the axis could either be normal (i.e. between zero and -30 degrees) or there could be left axis deviation (Burns, 2014). To determine which possibility is correct, we need to examine lead II.

Lead II sits at +60 degrees, and therefore divides the hexaxial system along a line running from -30 to +150 degrees (Houghton and Gray, 2014) (*figure 10*). In a normal axis, lead II must therefore be positive. We can therefore state that when both leads I and II are positive, the axis is normal (Rose and Kuhn, 2009). When lead I is positive, but lead II is negative, there is LAD (Burns, 2014).
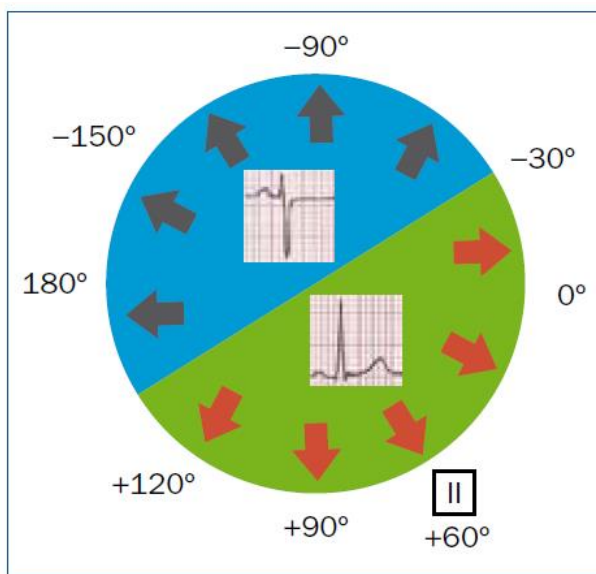
Figure 10. Lead II divides the hexaxial system along a line running from -30 to +150 degrees. If the QRS is positive in lead II, the axis must fall in the bottom half. If lead I is also positive, the axis is normal.

Hopefully this makes sense, but if you are struggling to understand the logic of axis determination, don't despair. Simply learning which leads are positive or negative in each type of axis will get you by in clinical practice. These are summarised in *table 2*. You may well find that with practice your understanding improves, and you are able to work out the axis from first principles.

|	Lead I	Lead aVF	Lead II
Normal axis	**+**	**+ or -**	**+**
Left axis deviation	**+**	**-**	**-**
Right axis deviation	**-**	**+**	**+ or -**
Extreme axis deviation	**-**	**-**	**-**

Table 2. Polarity of leads in each type of axis (+ = positive, - = negative)

Isoelectric lead approach

This approach can be used to determine the axis more accurately, and builds on the logic of the quadrant approach (Davies, 2007). Its key component is identification of the most isoelectric limb lead. Using this system, the QRS axis can be located to within 10 degrees (Garcia, 2015).

If you think back to the principles that we established earlier on, you might remember that when a wave of depolarisation is travelling at 90 degrees to an ECG lead, that lead will be isoelectric (Garcia, 2015). This principle can be applied to the cardiac axis. If we locate an isoelectric limb lead, the axis will be at 90 degrees to that lead. This gives us two possible answers, in other words 90 degrees to the left, or 90 degrees to the right (Burns, 2014). If we already know which quadrant the axis lies in,

we know which of the two possible answers is correct (Davies, 2007). This will be clearer with an example, so let's look at the ECG in *figure 11*. For clarity, we have cut away everything except the limb leads.
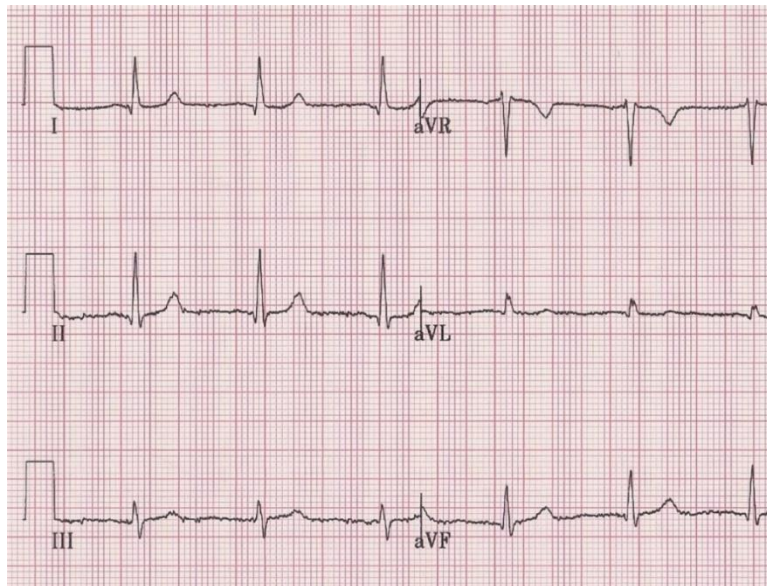
Figure 11. Using the isoelectric lead to locate the axis.

First, let's locate the axis using the quadrant system. Both I and aVF are positive, so the axis lies in the bottom right quadrant (Garcia, 2015). This is a normal axis, but where is it exactly? By examining each limb lead, we can see that lead III is isoelectric – its QRS has equally positive and negative parts. The axis must therefore lie at 90 degrees to that lead. Lead III sits at +120 degrees, so 90 degrees to that lead is either +30 or -150 degrees (*figure 12*). It can't be -150 degrees because we know that the axis is in the bottom right quadrant, so the axis is +30 degrees. In fact, the ECG machine calculated this axis as +37 degrees, so we are within 10 degrees.
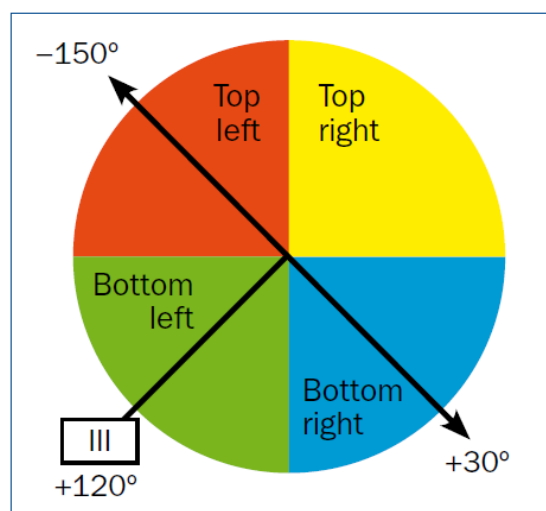
Figure 12. If lead III is isoelectric, the axis must lie at 90 degrees to it. This is either +30 or -150 degrees. Using the quadrant approach tells us which one it is, in this case +30 degrees.

Now, you might be thinking that this seems deceptively simple, in which case you'd be right. In many cases, there is no isoelectric limb lead (Burns, 2014). If this is the case, we have to make a small adjustment to our method. Firstly, we select the limb lead that is closest to isoelectric, or if none are biphasic, the one with the smallest amplitude (the least tall) (Garcia, 2015). Let's look at another example in *figure 13*.
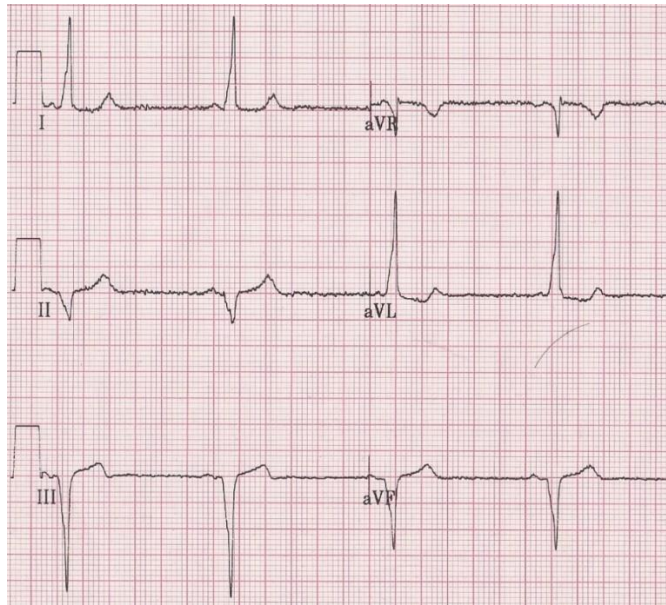
Figure 13. When there is no isoelectric lead, select the smallest lead.

Let's start with quadrants again. Lead I is positive and aVF is negative. This puts the axis in the top right quadrant (Burns, 2014). Lead II is negative, so the axis is between -30 and -90 degrees, meaning there is LAD (Surawicz et al, 2009). Can we locate the axis more exactly using an isoelectric lead? There are no biphasic leads, they are all completely positive, or completely negative, so we choose the smallest amplitude, which is lead II. Lead II sits at +60 degrees, so the axis must near to -30 or +150 degrees. Clearly it is -30 degrees, because we have placed the axis in the upper right quadrant. Is the axis at -30 degrees exactly? No, because lead II is negative, not isoelectric. Garcia (2015) suggests that when the smallest, or most biphasic lead, is not isoelectric, the axis lies either just beyond, or just before 90 degrees. By adding or subtracting 10 or 20 degrees, depending on how far the lead is from isoelectric, we can place the axis to within 10 degrees, as shown in *table 3*.

QRS morphology in smallest / most biphasic lead	Approximate location of axis
Positive part at least twice the size of negative part	70 degrees to the lead
Positive part larger, but less than twice the size of negative part	80 degrees to the lead
Isoelectric (equally positive and negative)	90 degrees to the lead
Negative part larger, but less than twice the size of positive part	100 degrees to the lead
Negative part at least twice the size of positive part	110 degrees to the lead

Table 3. Locating the axis using the most isoelectric, or smallest, limb lead.

In the case of *figure 13*, the QRS in lead II is entirely negative, suggesting the axis is between 100 and 110 degrees from the lead. This places the axis between -40 and -50 degrees, well within LAD territory. In fact, the ECG machine calculated this axis as -41 degrees. So why does this patient have LAD? If we look carefully we can see that there is a short PR interval, a broad QRS, and a delta wave. The patient has pre-excitation due to an accessory pathway (Mark et al, 2009).

Clinical relevance of QRS axis

The final topic that we need to consider is the use of QRS axis in clinical practice. *Table 1* lists some of the more common causes of axis deviation, but leaves unanswered the question of how we distinguish between them. In some instances, such as our patient with pre-excitation, systematic evaluation of the ECG alone can provide a diagnosis (Houghton and Gray, 2014). More commonly, however, ECG findings must be correlated with patient history, physical examination, and other diagnostic tests (McGee, 2009). It is often these other tests, rather the ECG, that confirm the cause of axis deviation. A good example of this is the use of echocardiography to confirm left ventricular hypertrophy (Oxborough, 2008).

This lack of direct relationship between the QRS axis and a diagnosis is often a cause of concern for students. If the QRS axis doesn't tell us what's wrong with the patient, they ask, what is the point of learning (sometimes painfully) how to work it out? The answer is that QRS axis provides important supporting evidence for many conditions, and may be the first clue that suggests a diagnosis (Kuhn and Rose, 2008). Perhaps more importantly, if all other causes of axis deviation have been excluded, a diagnosis of fascicular block may be made (Bennett, 2013). These blocks have important diagnostic, and prognostic value, that makes their identification alone a reason to understand the QRS axis.

Fascicular blocks

In this series of articles, we have, until now, described the left bundle branch as a single entity. This is a common simplification, and we now need to move beyond it. Most people are familiar with the idea that the His bundle divides within the interventricular septum to form the left and right bundle branches (Sampson and McGrath, 2015). It is less widely appreciated that the left bundle branch subdivides soon after it leaves the His bundle, forming a number of interconnected pathways that supply the various aspects of the LV and septum (Houghton and Gray, 2104). For functional purposes, these pathways are considered as two distinct sub-branches, or fascicles; the left anterior fascicle, and left posterior fascicle (Kumar et al, 2013).

The anterior fascicle is a relatively thin structure that runs down the front of the heart, activating the anterolateral walls of the LV (Josephson, 2010). Its blood supply comes from a single coronary artery. In contrast, the posterior fascicle is broader, more robust, and is supplied with blood from two coronary arteries (Rose and Kuhn, 2009). It travels inferiorly down the back of the LV, carrying depolarisation into the posterior and inferior walls. There are multiple anastomoses between the two fascicles, which means that they are connected electrically into one larger system (Kumar et al, 2013).

Fascicular block, also known as hemiblock, occurs when one fascicle is diseased, and fails to conduct the electrical impulse (Houghton and Gray, 2014). Depolarisation occurs normally in the other

fascicle, and spreads across to the affected side of the heart via the anastomoses between the fascicles. This alters the net direction of depolarisation, and therefore the QRS axis (Rose and Kuhn, 2009). In left anterior fascicular block (LAFB), left axis deviation is seen. In contrast, left posterior fascicular block (LPFB) causes right axis deviation (Hampton, 2013).

Various other ECG features are associated with fascicular blocks, and these are listed in *Table 4*. Several points are worth noting. Firstly, although fascicular blocks delay ventricular depolarisation slightly, the QRS does not exceed 120ms (Burns, 2014). Secondly, the current American Heart Association definition suggests that LAD is at least -45 degrees when it is caused by LAFB (Surawicz et al, 2009).

Left anterior fascicular block	Left posterior fascicular block
QRS axis between -45 and -90 degrees	QRS axis between +90 and 180 degrees
qR pattern in lead aVL	rS pattern in leads I and aVL
R-peak time in lead aVL of 45ms or more	qR pattern in leads III and aVF
QSR duration less than 120ms	QRS duration less than 120ms

Table 4. ECG features of fascicular blocks (Surawicz et al 2009)

In terms of clinical practice, there are two aspects of fascicular blocks that are important. The first is that they indicate damage to the distal conduction system (Vogler et al, 2012). While this may be due to age-related degeneration of the conduction tissues, it may also result from structural heart diseases such as coronary artery disease (Chow et al, 2012).   It seems logical that people newly diagnosed with fascicular block should undergo screening for underlying cardiovascular disease (CVD). This is certainly so in the case of LPFB, which is rare, and suggests a greater degree of myocardial damage given the robust nature of the posterior fascicle, and its dual blood supply (Bennett, 2013).

The need for screening in the case of LAFB is less well established, with a traditional view that it carries a relatively benign prognosis, and might even be considered a consequence of aging (Josephson, 2010). This view was recently challenged by Mandyam et al (2013) who demonstrated an association between LAFB and atrial fibrillation, chronic heart failure and death. This study was small, however, and a subsequent study of a large, primary care population failed to find any relationship between LAFB and CVD (Nielsen et al, 2014).

The second important aspect is that fascicular blocks may be discovered in association with disease in other parts of the distal conduction system. This indicates not only a greater degree of damaged conduction tissue, but also a higher risk of progression to complete heart block (Houghton and Gray, 2014). If, for example, fascicular block is found in association with right bundle branch block, the implication is that two out of three conduction pathways to the ventricles are blocked. This is commonly referred to as a 'bifascicular block' (Swift, 2013).

Even more alarming is a finding of right bundle branch block, fascicular block, and first-degree atrioventricular (AV) block.   This implies that there is disease, and impaired conduction, in the one functioning fascicle, and is commonly, if inaccurately, referred to as 'trifascicular block' (Rose and Kuhn, 2009). If this remaining fascicle fails, complete heart block will ensue (Vogler et al, 2012). Patients with trifascicular block require careful follow up, and ongoing evaluation for higher degrees of AV block in the functioning fascicle (Brignole et al, 2013). If more significant AV block is detected,

a permanent pacemaker must be implanted because of the high risk of complete heart block (Bennett, 2013).

Because the terms 'bifascicular' and 'trifascicular' block are inaccurate, the American Heart Association recommends that they are avoided, and suggests describing these complex blocks according to their constituent features (Surawicz et al, 2009).   Accordingly, the ECG in *figure 14* shows right bundle branch block, left anterior fascicular block, and 2:1 AV block. The patient presented to her GP with dizziness and collapse, and was transferred to the emergency department by ambulance. She was admitted to a monitored bed on the Coronary Care Unit, and underwent pacemaker implantation the same night.
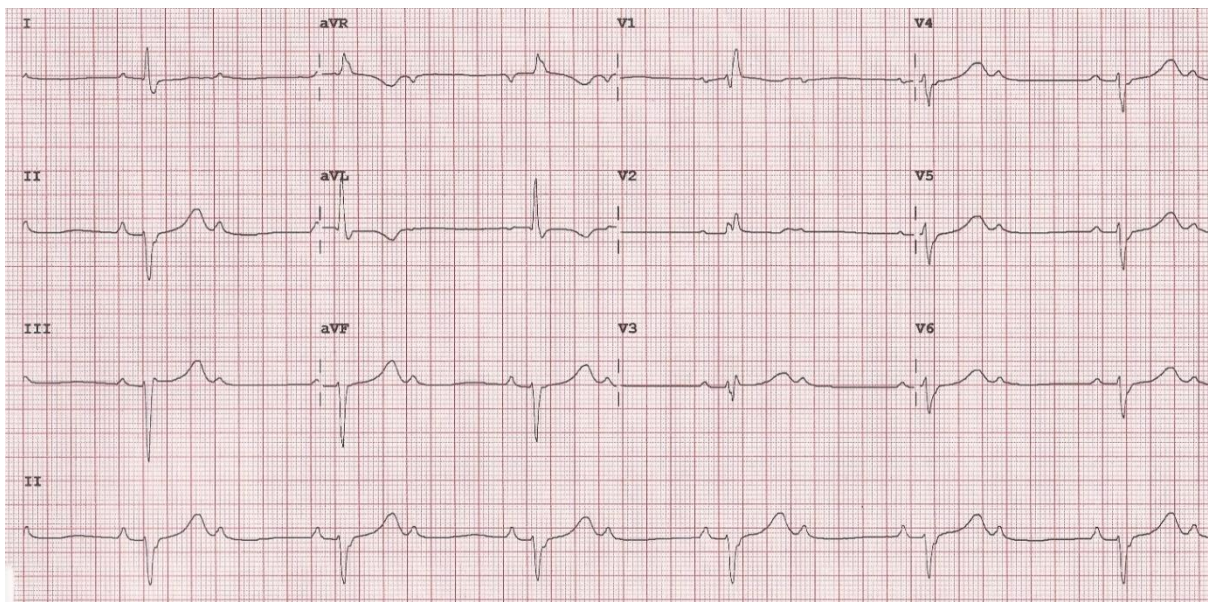
Figure 14. Right bundle branch block, left anterior fascicular block, and 2:1 AV block. The patient received a permanent pacemaker.

Conclusion

The QRS axis is an important measurement on the 12-lead ECG, albeit one whose measurement is subject to various pitfalls and inaccuracies. These include a wide natural variation in normal values, changes that occur in response to ageing and body shape, and susceptibility to wild inaccuracy if limb leads are transposed. QRS axis is also much misunderstood, and seen as difficult to master.

Despite these challenges, accurate assessment of the QRS axis is a vital part of systematic 12-lead ECG interpretation.   Although axis deviation may be a benign and normal finding, in many cases it reflects changes in the structure or electrical activation of the ventricles. This has important ramifications in terms of diagnosis, prognosis, and further evaluation of the patient. This is especially so in the case of fascicular block in association with right bundle branch block, in which case the development of AV block in the remaining fascicle can herald the need for permanent pacing.

In this review, we have evaluated the importance of QRS axis, and described how and when it can be useful in clinical practice. We have also highlighted potential problems, and explained how they can be recognised and avoided. We have set out several simple methods for axis determination that can be used at the bedside, or in the clinic room.   We hope to have provided readers with a working knowledge of this important topic, which though challenging, provides further insight into the 12-lead ECG.

Next month, we review our progress so far by revisiting our 12-lead ECG interpretation tool. We also tackle another important subject in 12-lead ECG interpretation, the signs of chamber enlargement.

Key points

- QRS axis represents the net direction of depolarisation within the ventricles, and is measured using the limb leads. A normal axis lies between -30 and +90 degrees; anything outside of this range is referred to as axis deviation.

- Axis deviation may be a normal variant, but is often the result of structural or electrical heart disease. Incorrect limb lead placement also affects axis, and should be suspected when other unusual features such as P-wave inversion and a positive QRS in lead aVR are seen.

- Axis is calculated by most ECG machines. This is usually highly accurate, but practitioners should be able to verify axis manually, in case of machine error. Several methods can be used, including the quadrant approach and identification of the isoelectric lead.

- If all other causes of axis deviation have been excluded, a diagnosis of fascicular block may be made. This has important prognostic implications, especially in the patient with co-existing right bundle branch block and first-degree AV block. In these individuals, careful evaluation must be made for higher degrees of AV block. If they are found, a pacemaker should be implanted.

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