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# Table of Contents

<b>Editorial: The Art and the Science of Healing</b> <i>Victor Grech, Charles Savona Ventura, Joseph M Cacciottolo</i>	1.
<b>The implications of the abortion referendum in Ireland</b> <i>Pierre Mallia</i>	4.
<b>Pseudohyponatraemia – A literature review</b> <i>Desiree Seguna, Miriam Giordano Imbroll, Mark Gruppetta</i>	8.
<b>The difficulties in identifying and grafting an intramuscular coronary artery</b> <i>Andre' Navarro, David Sladden, Aaron Casha, Alexander Manche</i>	13.

# The Art and the Science of Healing

Victor Grech, Charles Savona Ventura, Joseph M Cacciottolo

The human condition cannot be compartmentalized into separate and convenient facets. The individual, as well as the society he/she lives in, is a complex conglomeration of experiences that transcend all aspects of life. We are what we are because of the way we are made up and because of the experiences we are subject to throughout our lives – a combination of nature and nurture. The Medical Humanities (MH) is an interdisciplinary field of medicine which attempts to personalise medical care, allowing the medical practitioner to apply patient management within the broad canvas that makes up the individual. MH includes all aspects of the humanities (such literature, philosophy, ethics, history and religion), the social sciences (such anthropology, cultural studies, psychology, sociology, and geography) and the arts themselves (including literature, theatre, film, and visual arts), and the application of all of these to medical education and medical practice.<sup>1</sup> MH is mainly concerned with training medical practitioners: “to cure sometimes, to relieve often, to comfort always”.<sup>1</sup>

The Humanities, Medicine and Sciences Programme (HUMS) was set up and formally recognised and endorsed by the Senate of the University of Malta, and inaugurated by the then Rector of the University, Professor Juanito Camilleri on 27 January 2012. HUMS seeks to encourage university staff to explore the interfaces between the humanities and medical science, and aims to facilitate and disseminate cross-disciplinary research. The need to develop this structure was felt as scholars of the humanities, social sciences and the arts have always been interested in matters pertaining to health and illness, as both are crucial to the very core of human experience. On the other hand, doctors and scientists very often also look upon their work as a service that improves and enriches the human experience in the knowledge that the cultural experiences are an essential and integral part of medical management of the individual. Indeed, university graduates in the not too distant past boasted of a broad grounding which included a common trunk of knowledge in the sciences and humanities, such that the medical curriculum included study units that addressed the relevant aspects of the humanities. This is not always possible within the modern educational process since the medical knowledge base has become so vast.

The Centre for the Liberal Arts and Sciences (CLAS) in the University of Malta coordinates and administers the University's Programme in the Liberal Arts and Sciences (PLAS). PLAS enables students to follow ‘stand alone’ units from a broad array of subjects in the arts and sciences. PLAS also allows students to use accumulated units to achieve a Certificate, a Diploma, a Higher Diploma and a Bachelor’s degree in Liberal Studies, without any temporal constraints.

HUMS helps to run the PLAS Module entitled “The Art and the Science of Healing” (LAS2025). This is a four ECTS stand-alone study unit that will next run in second semester of the academic year 2018/2019. All of the lecturers are doctors with a particular interest in one or more aspects of the humanities (table 1). The aim of the course is to

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## Editorial

widen the horizons by disseminating cross-disciplinary fertilization. HUMS and CLAS encourage prospective colleagues not only to attend, but also to inform any potentially interested

individuals about this module which comprises a short but incisive interdisciplinary foray.

*Table 1: The Art and the Science of Healing (LAS2025)*

Speaker	Title
J Cacciottolo	Health and illness as social concepts   Landmarks in the history of medicine 1
J Cacciottolo	Landmarks in the history of medicine 2
C Savona-Ventura	Key points in Maltese medical history 1
C Savona-Ventura	Key points in Maltese medical history 2
C Savona-Ventura	The body image
J Cacciottolo	The face in medicine, art and technology
A Manché	The discovery of the circulation
A Manché	Hearts and egos: cardiology and cardiac surgery
V Grech	Doctors and Science fiction
C Mallia	Art and medicine 1
C Mallia	Art and medicine 2
J Cacciottolo	The breast in art, medicine and politics
J Cacciottolo	The concept and evolution of medical education
C Savona-Ventura	Medical education in Malta

\* All lectures are held weekly between 18.00-20.00.

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#### Cover Picture:

'Queen Elizabeth's Valletta'

*Oil on board*

By Victor Grech

The High Commissioner in London HE Norman Hamilton relinquished his duties on 31 July 2018. As is customary, he was called upon by the Marshal of the Diplomatic Corps, HE Alistair Harrison (Marshal of the Diplomatic Corps) who presented him with a gift from Her Majesty The Queen. To reciprocate, the High Commissioner presented the Marshal with a gift for Her Majesty, a painting by consultant paediatrician Prof. Victor Grech.

### **Corinthia Group Prize in Paediatrics, 2018**

The Corinthia Group Prize in Paediatrics for 2018 was awarded, jointly for the third time, to Dr Stefanie Marie Agius and Dr Naomi Piscopo, who both obtained the highest aggregate mark over the combined examinations in Paediatrics in the fourth and final year of the undergraduate course. Whilst offering our congratulations to Drs Agius and Piscopo, we would also like to congratulate all those who performed admirably during the undergraduate course in Paediatrics. In the accompanying photograph, Dr Agius and Dr Piscopo are seen receiving their prize from Professor Simon Attard Montalto, Head of Paediatrics, in the Medical School. Finally, the Academic Department of Paediatrics and Medical School remain indebted and are extremely grateful to the Corinthia Group for their ongoing support.

### **Professor Simon Attard Montalto**



# The implications of the abortion referendum in Ireland

Pierre Mallia

## Abstract

This paper reviews the implications of the abortion referendum in Ireland along with the background that led to the referendum.

## Review

This paper concerns the implications of the abortion referendum in Ireland, or rather, to be precise, a vote in favour of the Thirty-sixth Amendment of the Constitution of Ireland Bill 2018,<sup>1</sup> which was intended to repeal the Eight Amendment of the same constitution which guarantees the unborn child for the right to life unless the pregnancy is life threatening. The current Bill will (by an act of parliament) replace Article 40.3.3 of the Constitution which was added in 1983 and subsequently amended in 1992.<sup>2</sup>

One must immediately point out that the 1983 amendment made no reference to the philosophical doctrine of double effect whereby harm can be caused even if it is foreseen but is not intended and indirect. As we will see this has important consequences in a Catholic Hospital which was accused, rightly so, of a medical misadventure in Ireland causing the death of a woman who was 17 weeks pregnant, where the termination could have been done also on principle of double effect.

## The death of Savita Halappanavar

Savita Halappanavar was 31 years old and 17 weeks pregnant. She died on 28<sup>th</sup> October 2012 after being admitted a week before when it was diagnosed that she would miscarry. She requested a termination at that stage; a request which was denied as she was not deemed to be in danger of losing her life. During the subsequent seven days she developed sepsis. By the time it was diagnosed and an attempt to treat with misoprostol was started, she had already delivered the baby but the ongoing sepsis caused a cardiac arrest later. Indeed the doctors were accused in the Coroner's Inquest that there was poor communication in the case, poor management, poor record keeping, and indeed a poor system which led to a failure to diagnose the sepsis early enough. This could have saved the patient's life.<sup>3</sup>

The death is said to have caused an arousal by the public and media which led to the 36<sup>th</sup> amendment of 2018. It is important therefore to understand why a law which allows the termination of pregnancy if the life of the woman is in danger can cause, even if other issues which were criticised by the coroner were correctly in place, doctors to hesitate and wait for complications like sepsis to develop. There is an interplay between understanding the law and indeed understanding moral issues, especially, in the case the hospital in Galway being a Catholic Hospital, a clear understanding of the principle of double effect which is enshrined in the magisterium of the Catholic Church and written clearly in the Church's Catechism available for the public, and supposedly within the realm of a medical curriculum. If a Law deliberately leaves something out, it is done with intention and therefore the principle of double effect is accepted under its aegis.

Clearly enough gynaecologists do not hesitate to remove ectopic pregnancies and a cancerous pregnant uterus which would involve the removal of the unborn child. This follows the doctrine of double effect, which has the following conditions:<sup>4</sup>

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1. That the action itself be good or at least neutral
2. The good effect is the intended outcome and not the bad (which is seen as indirect)
3. The good must not be brought about by a bad (or evil) effect
4. That there be a proportionately grave reason for permitting the evil.

So this raises the question, even if the doctors were correct in assuming that the life of the woman was in danger, whether such a case could have been more effectively (and efficiently) handled by invoking this principle. Clearly:

1. The diagnosis that the baby was going to be miscarried was made.
2. The request of the patient was ignored, or at least not considered in its possibility by thinking about double effect; something which ought to be in every doctor's duty.
3. Doctors took a risk by waiting for a 'natural' outcome.
4. It was clear that the death of the baby was foreseen and accepted.

At the end of life, when one gives morphine, it is clearly understood that even if this hastens death, once death is accepted as the outcome, this can be done. This specific case is even (for Catholics) listed in the Catechism (5) under *Ordinary Care*. When death is an outcome therefore, the comfort of the patient is not only paramount, but also seen as a 'charitable' thing to do. So why did the Irish doctors fail in this case? Clearly there can only be two reasons, the first being that abortion is a very contended and controversial issue in a Catholic Country, and secondly (as the HSE in Ireland recommend) there was a lack of training of health professionals about the law – which usually clouds, out of fear of breaking the law, the judgement of doctors.

Clearly the law would not allow termination unless there was an immediate physiological threat. It will also allow for termination if there is a risk of suicide. Such calls are not that easy to follow. Can one give the benefit of the doubt. It is clear however that the law uses the term 'physiological' and not 'pathological'. Following philosophy of law, these terms have a clear intention. One need not wait for a physiological condition to develop into a pathological one. There was in this case a clear physiological process of miscarrying (even

though this can clearly be defined as pathological). One notes that the termination was inevitable and that the request for an abortion was made after the patient had broken her waters. What was required was expediency.

Clearly, administering misoprostol early would have satisfied the principle of double effect:

1. The action would have been good (or at least indifferent) since the waters were already broken, the delivery had started, and the miscarriage process had been diagnosed.
2. The good effect was the intended outcome (it could never have been to kill a baby whose death was the inevitable outcome – as in the morally equivalent case of administering morphine at the end of life).
3. The good effect could not have been brought about by the evil effect, which was already in process.
4. There was clear proportionality.

Even if there can be doubt to the third condition, it would have only been a charitable thing to do to a mother whose baby is dying to hasten the process, once labour had started. Moreover avoiding risk falls under the *primum non nocere* doctrine which includes avoiding harm and injury<sup>4</sup>

One can tentatively conclude that either fear of the law or over-enthusiastic of the application of catholic-moral principles could have been the overall cause.

### Implication for Ireland

One of the biggest questions is whether the abortion law in Ireland will be as liberal as that of Britain? In matter of fact abortion in the UK is illegal. There is however an abortion Act<sup>6</sup> which allows termination of pregnancy up to 24 weeks' gestation if there is a serious health issue. The document needs to be signed by two doctors, although recently it was contended that this ought to be reduced to one, raising the question whether it will then be easier, but also an issue of trust. Health is a broader term than 'medical', as it includes not only the biological issues, but also psychosocial ones. Therefore someone who has three children and is a working mother in a difficult socio-economic situation will qualify for a termination. Moreover the abortion Act has an amendment which also allows for the termination of fetuses

with congenital anomalies.

That the law in the UK actually makes it illegal to have an abortion unless for health reasons, is clear from the fact the Society for the Protection of the Unborn Child (SPUC) had taken to court a drug company which produced the emergency contraceptive pill which was claimed to possibly also cause a miscarriage. The court decided in favour of the drug company as the term miscarriage implies that the woman is 'carrying' and that therefore implantation has occurred. Emergency contraception does not cause a miscarriage. Of course the term miscarried fell into the trap of philosophy of language as clearly the SPUC did not imply that. The British Episcopal Conference then made a statement on when emergency contraception can be used.

A second example of the illegality of abortion is the guideline of the Royal College of Obstetricians and Gynaecologists on laparoscopic removal of ectopic pregnancies.<sup>7</sup> This method of removing the embryo in an ectopic pregnancy whilst preserving the tube has been seen in some circles as a 'direct' destruction of the embryo and therefore laparoscopic removal cannot satisfy the principle of double effect. The 'pound of flesh' is necessary. The guidelines will recommend laparoscopic removal only under certain circumstances, for example that only one tube is remaining.

Nevertheless the broad definition of 'health' and the termination of foetuses with congenital anomalies have given rise to quite a liberal law. There is clearly a danger for Ireland that this can be the case unless it restricts the law only to medical reasons, albeit not necessarily life threatening. This would bring about certain problems: which medical reasons is one to accept? Will gestational induced diabetes or hypertension count? If one cannot restrict oneself to medical, what constitutes a 'serious risk' to health has to be defined if Ireland is not to follow the UK. As pointed out, if the law deliberately fails to define this, it will have done so with an intention to leave it open to interpretation.

### Moral issues

Clearly laws of abortion do not (or need not) question that an embryo is a human life. Whilst philosophical some say that one cannot see the deliberate killing of a two year old child and that of a fertilized egg as morally equivalent, others

(especially the more conservative) do. But no law has equated this, not even locally. In the local scenario the woman is given the benefit of the doubt that she may have been psychologically affected and the maximum sentence is three years (and not life) imprisonment. No other law makes this kind of exception.

Clearly abortion is more about women's rights. Often the term 'innocent child' is used. This is mostly rhetoric and cannot hold either philosophical or legal ground. Everyone is innocent until proved guilty in the eyes of the law. If a woman has to have a right to an abortion, clearly one would have to either over-ride the right to life of the woman over that of the foetus, or see the moral weight of a developing human as increasing over time. Theologically and for conservative philosophy this will not do. But many do see reason behind the greater gravity of killing an eight month from a two week gestation. The question then becomes *when does the moral value of the foetus outweigh the right of the woman to abort it*. This certainly would not be an easy question to answer and many countries have defined it arbitrarily and at different stages. Clearly the fact that all European countries except Malta are now in favour of abortion has its weight, if anything because it shows what 'reasonable society' (Defining 'reasonable' through the eyes of the law from 'reasonable person standard') has seen fit.

### Local Implications

Can one see emergency contraception (EC) as having opened the window for abortion? Clearly this has been pointed out even in the Parliamentary Social Affairs Committee<sup>8</sup> but probably not. Abortion is a much larger issue than emergency contraception. The latter was about preventing pregnancy and not about terminating it. The argument in fact centred around whether EC was abortifacient – some arguing that it was and others that it was not. The principle of not killing a baby was accepted. Of course political arguments are not only emotive but often deliberately deceptive. The true argument should have been, 'even if EC was possibly abortifacient, what are the chances that it will'. Here WHO rates of pregnancy could have helped to show that after 12 hours (hence morning after) the chances of a pregnancy are 0.5%. The question then would have been one of when this small chance outweighs any risk for an (unknown)



abortion.

The question of abortion can only come about with a government which has the confidence it will remain in place notwithstanding opposition. There is also no guarantee that all parliamentarians of each side will vote the same. Local women can easily have access to abortion, and if it is seen that this is a women's health issue, the EU may even intervene to have governments pay for abortions abroad (although up till now the European Court of Justice has upheld Member States' laws). Probably no one can oblige a woman to remain pregnant; one can only appeal to women to *think* about the child they are carrying. Conversely one ought to seriously consider terminations when the life of the woman is seriously in danger in order to avoid what can be a very complicated interpretation of the principle of double effect.

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# Pseudohyponatraemia – A literature review

Desiree Seguna, Miriam Giordano Imbroll, Mark Gruppetta

## Abstract

Hyponatraemia often poses a diagnostic dilemma, brought about by inadequate work-up and inappropriate management. In order to make the correct diagnosis, an understanding of the pathophysiology and classification of hyponatraemia is essential. In this review, focus is made on the diagnosis of pseudohyponatraemia including the causes, when to suspect it and how to diagnose it. Different analytical methods are discussed, including flame emission spectrophotometry, and ion-specific electrode (ISE) potentiometry and the role they play in diagnosing pseudohyponatraemia. The measured and calculated osmolalities and their use to calculate the osmolal gap are explained. Finally, a discussion follows on the aetiologies of pseudohyponatraemia, strategies to circumvent this problem and the relevance of clinching the diagnosis in clinical practice.

## Keywords

pseudohyponatraemia, hyperproteinaemia, hyperlipidaemia, ion-specific electrode potentiometry, osmolal gap

Measurement of serum sodium concentration is amongst the most commonly requested tests in clinical practice. A diagnosis of hyponatraemia is made in up to 2% to 3% of hospitalised patients.<sup>1</sup> However, it is frequently overlooked, misdiagnosed and mismanaged. Measurement of serum osmolality and assessment of fluid status are the crux to distinguishing between the different causes of hyponatraemia, while giving due consideration to the possibility of a spuriously low serum sodium level – *pseudohyponatraemia* (figure 1).

For around thirty years, flame emission spectrophotometry (FES) was the technique of choice for measuring the major cations, sodium and potassium. Although still in use as a reference method, in the 1980s FES was replaced across most laboratories by ion-specific electrode (ISE) potentiometry. The latter measures the potential difference across a reference electrode and a measuring electrode being exposed to the selected ion (in this case sodium). Two ISE techniques are available for measurement of plasma sodium concentration – direct and indirect ISE potentiometry. With direct ISE potentiometry, the sample is presented to the measuring electrode undiluted, whereas indirect ISE potentiometry requires that the sample is first diluted in a buffer.<sup>3</sup> Of the two techniques, *indirect* ISE is the more widely used, as diluting the sample allows for the serum sodium ionic activity, measured in millivolts (mV), to be used as a close approximation of the serum sodium concentration. Only atoms that undergo ionisation are activated, and this ionisation takes place via a pre-analytical dilution of 1:10.<sup>4</sup> This method is used in over two-thirds of laboratories across the United States and likewise affects the measurement of other similarly measured ions including potassium, chloride and calcium.<sup>5</sup> However, since the concentration of sodium is far greater than that of the other ions, the analytical error is also greater. On the other hand, point-of-care machine analysers (such as blood-gas analysers) use *direct* ISE and measure the sodium activity without requiring a dilution step, hence allowing for direct measurement of the sodium

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concentration in plasma water.

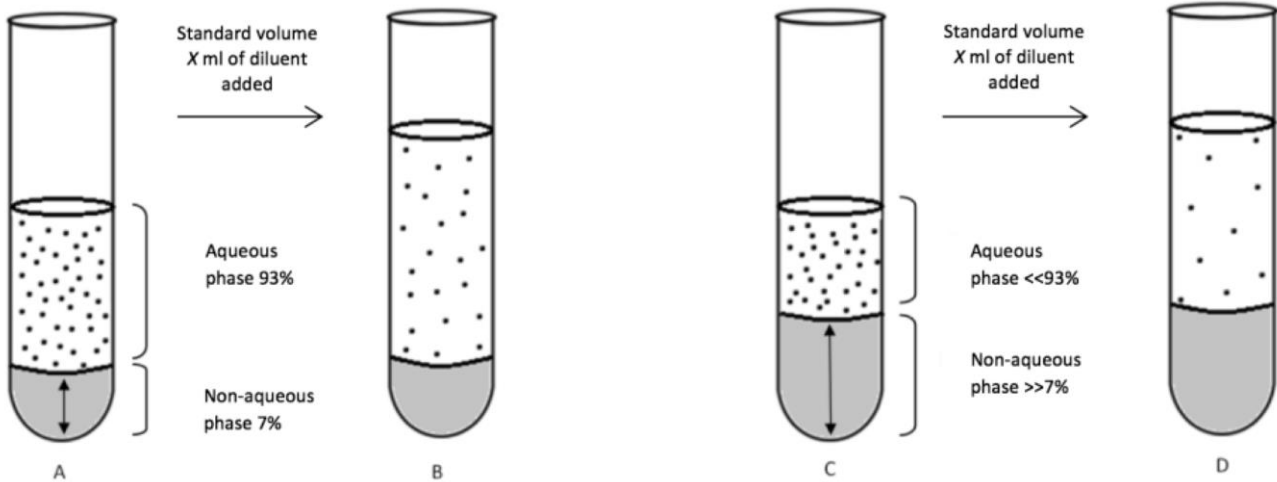
In the healthy subject, water constitutes 93% of plasma volume, whilst the remaining 7% consists of undissolved particles, mostly lipids and proteins.<sup>6</sup> All plasma electrolytes are confined to the aqueous phase and hence it is the concentration of sodium in the aqueous phase that is physiologically relevant. In patients with severe hyperlipidaemia or hyperproteinaemia, the increased amounts of protein or lipid in the non-aqueous phase will occupy more than 7% of the total plasma volume and will hence alter the 93:7 aqueous to non-aqueous ratio. This ratio of 93:7 is the basis for

measuring serum sodium concentration using *indirect* ion-specific electrode (ISE) potentiometry. If the non-aqueous phase increases at the expense of the aqueous phase, then the serum sodium can no longer be predicted from the total plasma volume (aqueous plus non-aqueous) using this ratio. In patients with pseudohyponatraemia the sodium concentration in aqueous phase of plasma is normal, however *indirect* ISE potentiometry measures the serum sodium in the *total* plasma volume, without taking into account instances when the aqueous phase occupies less volume than usual (figure 2).<sup>7</sup>

Figure 1



Figure 2

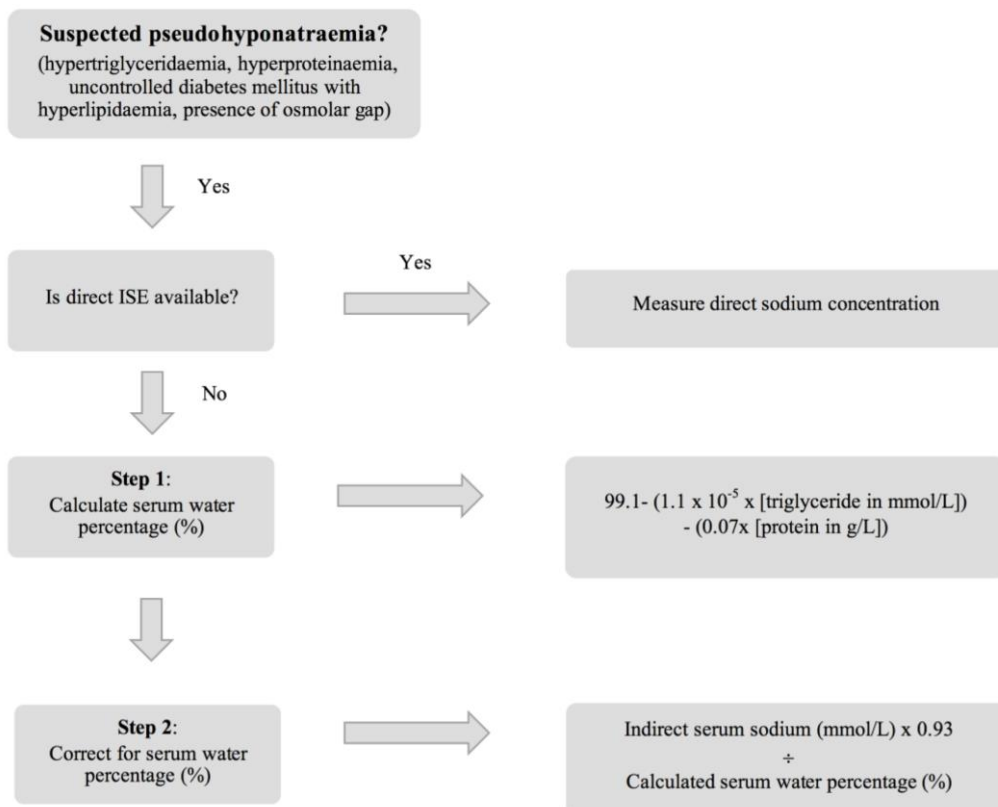


The easiest method to diagnose pseudohyponatraemia is by measuring serum sodium concentration using a direct ISE potentiometer (such as a blood gas analyser).<sup>8</sup> If this is not available, plasma triglyceride and total protein concentration can be used to calculate the percentage water content of serum, with a value less than 93% being in keeping with a possible diagnosis of pseudohyponatraemia.<sup>9</sup> The first step in calculating the serum sodium concentration requires the percentage of serum water, obtained using the following equation:<sup>10</sup>

$$\text{Serum water (\%)} = 99.1 - (1.1 \times 10^{-5} \times [\text{triglyceride in mmol/L}]) - (0.07 \times [\text{protein in g/L}])$$

The corrected sodium concentration is then calculated by multiplying the laboratory (indirect) serum sodium by 93% (i.e the normal serum water percentage) and dividing it by the calculated serum water % (calculated using the above equation). The second step allows for the adjustment of the calculated serum sodium to a normal serum water percentage (figure 3).

Figure 3



Pseudohyponatraemia should be suspected in the following circumstances:

- There is a significant discrepancy between the *measured* osmolality (which is normal in pseudohyponatraemia) and the *calculated* osmolality i.e. the presence of a raised osmolal gap, defined as the difference between the measured osmolality and the calculated osmolality (the calculated osmolality being lower than the measured osmolality in cases of pseudohyponatraemia). The measured serum osmolality remains unperturbed by changes in the ratio of the plasma constituents, as only the solutes which dissolve in the aqueous phase contribute to its measurement.<sup>11</sup>
- The serum sodium does not correlate with the clinical signs.<sup>12</sup>
- Hyponatraemia in a patient suffering from uncontrolled diabetes mellitus. Of note, the pseudohyponatraemia in this case is secondary to an associated hyperlipidaemia and should be differentiated from hyponatraemia caused by hyperglycaemia. In the latter case, glucose acts as an active osmole causing water to move from the intravascular to the extravascular space and hence resulting in a true, dilutional hyponatraemia secondary to an osmotic diuresis. As a rule of thumb, an increase of plasma glucose of 5 mmol/L results in a decrease in plasma sodium of 1.6-2.4 mmol/L.<sup>13</sup>
- The specimen is grossly lipaemic. For every 12 mmol/L increase in serum triglyceride levels, serum sodium decreases by approximately 1.5 mmol/L.<sup>14</sup>
- In patients known to suffer from a paraproteinaemia or being treated with intravenous immunoglobulin (IVIg). In this case each gram of monoclonal protein decreases serum sodium by 0.7 mmol/L.<sup>15</sup>

Interestingly the phenomenon of pseudohypernatraemia can conversely arise in patients suffering from hypoproteinaemia.<sup>5</sup> Also of note is that hypertriglyceridaemia is far more likely to cause pseudohyponatraemia than hypercholesterolaemia – this is because triglycerides have a 2.5-fold greater molecular weight ( $C_{57}H_{104}O_6 = 885.4$  g/mol) compared to

cholesterol ( $C_{27}H_{46}O = 386.7$  g/mol) which results in lack of visible turbidity when hypercholesterolaemia is the culprit.<sup>5,15,16</sup> Nevertheless, although uncommon, hypercholesterolaemia has been described as a cause of pseudohyponatraemia in the context of obstructive jaundice and elevated levels of lipoprotein X.<sup>17-22</sup> Extreme hypertriglyceridaemia, in excess of 10 mmol/L, results in an increase in the non-aqueous phase of plasma and contraction of the aqueous phase. Clinical manifestations may include lipaemia retinalis and eruptive xanthomata and unfortunately acute pancreatitis remains a very serious complication. It may result from a gene defect involving the activity of lipoprotein lipase (directly or indirectly) or may more commonly be precipitated by conditions such as poorly controlled diabetes, obesity, excessive alcohol consumption, hypothyroidism and lipodystrophy.<sup>23</sup>

### Conclusion

Pseudohyponatraemia is an artefactual reading occurring when the *measured* serum sodium is normal, but the *calculated* serum sodium is erroneously low, hence resulting in an increased osmolal gap.<sup>11</sup> The condition only arises in cases of severe hypertriglyceridemia and hyperproteinaemia (most commonly multiple myeloma<sup>24</sup>), when serum sodium is measured using *indirect* ISE potentiometry or FES, both of which involve predilution of the blood samples. The exclusion of sodium from the non-aqueous phase is the basis for understanding why predilution photometry can result in pseudohyponatraemia if the plasma volume occupied by the aqueous phase changes. As the lipid concentration increases, the water content in plasma decreases, and hence, the larger the error of pseudohyponatraemia. Whilst it is rare for serum triglycerides or proteins to rise to such high levels as to result in pseudohyponatraemia, it is of paramount importance that this artefact is recognised and *not treated* as true hyponatraemia. When in doubt, serum sodium should be measured using direct ISE potentiometry, as failure to recognise pseudohyponatraemia may lead to inappropriate choice of treatment and death from hypernatraemia.<sup>25-26</sup>

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# The difficulties in identifying and grafting an intramuscular coronary artery

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## Abstract

Myocardial bridging involves tunnelling of one of the coronary arteries through the myocardium, resulting in what are known as intramyocardial coronaries. While most patients with intramyocardial coronary vessels are asymptomatic, there is evidence that myocardial bridging may be the cause of sudden death. Given the low detection rate on coronary angiography, myocardial bridging may complicate coronary artery bypass grafting (CABG). This case report discusses a 72-year-old gentleman who underwent CABG, during which an undiagnosed intramuscular left anterior descending (LAD) coronary artery was found. With only the tapering end of the LAD visible at the apex of the heart, a small incision was made at this site and a 1mm probe inserted. At the uppermost reach of the probe the tip was felt to point superficial and therefore a second more proximal incision was performed. The left internal thoracic artery (LITA) was then successfully anastomosed with the proximal arteriotomy and a length of saphenous vein was used for anastomosis with the distal arteriotomy where the probe was originally inserted. The patient was discharged home 5 days post operatively.

## Introduction

Myocardial bridging occurs when a segment of epicardial coronary artery is situated beneath a band of myocardium, resulting in intramyocardial coronary vessels. It was first described in 1737 at autopsy and first detected on angiography in 1960.<sup>1-2</sup> The prevalence quoted in the literature varies greatly and an exhaustive anatomical study of over 1000 cadavers identified intramuscular coronaries in 26%.<sup>3</sup> The detection rates using conventional coronary angiography is significantly lower, at just 12%.<sup>4</sup> CT angiographic studies have identified myocardial bridges in up to 60% of people.<sup>5-6</sup> These rates are significantly higher than the detection rates on coronary angiography.<sup>7</sup> This is likely due to the fact that the features on angiography are more difficult to identify.

The importance of this anatomical variation is widely debated. Since the majority of coronary blood flow occurs in diastole the systolic compression rarely causes ischaemia. However there is some equivocal evidence that atherosclerosis is accelerated immediately proximal to the segment being compressed by the bridge, whilst the intramyocardial and distal portions are usually disease free.<sup>8-9</sup>

The commonest artery to be compressed by myocardial bridges is the LAD at 62.5%, with the marginal branch of the right coronary artery coming in second at 16.7%.<sup>10</sup> The length of artery covered by myocardium varies considerably from around 3mm to 40mm.<sup>7</sup>

Characteristically the intramyocardial coronary vessel is seen to buckle inwards during systole and in 7% of these is also seen to temporarily narrow during systole.<sup>11-12</sup> These angiographic findings were described by Portmann in 1960 and currently still remain the most common method of diagnosing myocardial bridging. However more advanced technologies such as coronary CT, intravascular ultrasound, intracoronary Doppler and fractional flow reserve, can help quantify the degree of compression.<sup>10</sup>

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## Case Report

While most agree that these anomalies are harmless when in isolation, there is no data on the prognosis of myocardial bridges in the context of coronary artery disease. There is anecdotal evidence of myocardial bridging potentially causing sudden cardiac death, with several studies noting them present in healthy young people who died suddenly with no other cause found at autopsy.<sup>13</sup> The LAD seems to be a culprit artery in these cases of sudden death, as is the length of artery covered and the depth of muscle it lies within.<sup>14</sup>

### Case Presentation

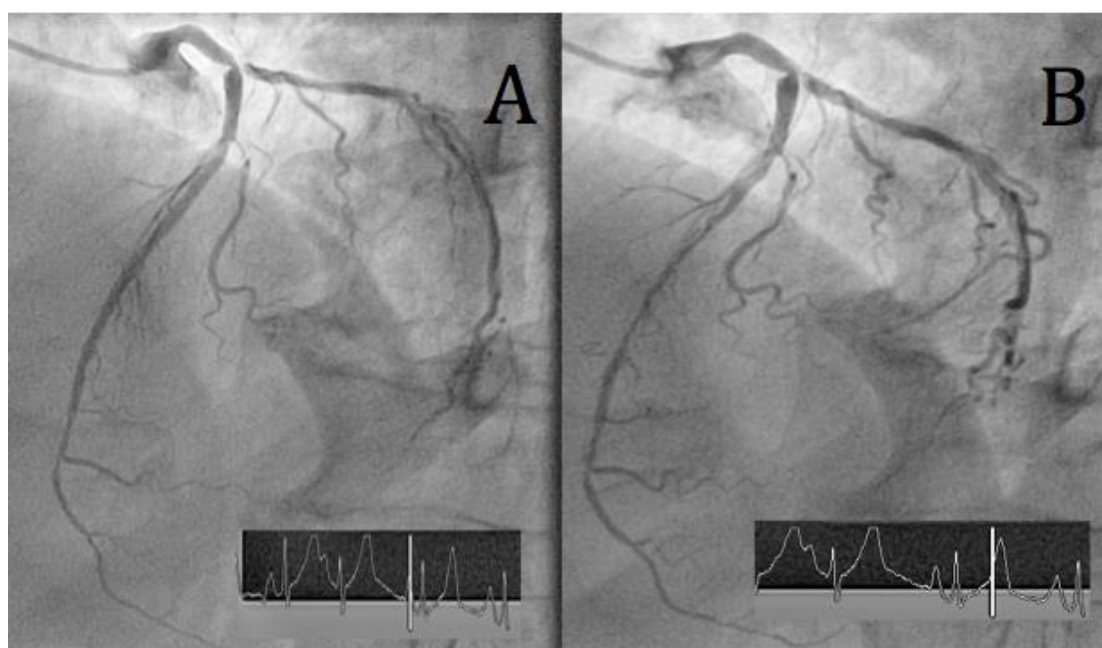
A 72 year-old male presented with angina. He was not a smoker and not diabetic, and presented with features suggestive of Parkinsonism. An exercise stress test was positive and a coronary angiogram was performed. This showed a tight stenosis of the distal left main coronary artery, systolic compression of a long-segment of the mid-LAD, with further stenotic disease at the origin of this segment (figure 1). His ejection fraction on echocardiography was 82%, Parsonnet score of 15 and logistic Euroscore of 3.26%. The patient was prepared for a CABG, with planned grafts to the LAD and the obtuse marginal (OM) branch of the circumflex artery.

Standard median sternotomy was performed with harvest of the LITA and simultaneous minimally-invasive long saphenous vein harvest from the thigh. Surgery was performed with conventional atrio-aortic cardiopulmonary bypass at normothermia and myocardial protection was with antegrade cold blood cardioplegia. The native vessels were inspected and while the OM was clearly visible the LAD was not. On closer inspection the tapered end of the LAD was visible at the apex of the heart. This was considered an unsuitable site for grafting as the LITA was not long enough and the calibre of the distal LAD very small.

Following the OM anastomosis a limited opening was made in the LAD at the apex and a 1mm metal probe was inserted retrogradely. The proximal LAD was then exposed proximally by cutting deep into the myocardium, using the probe as a guide. The LITA was anastomosed at this site and a further length of saphenous vein anastomosed to the distal LAD arteriotomy.

The patient was discharged home after 5 days without complications. At six months follow-up he remains well with good exercise tolerance and no recurrence of angina.

**Figure 1:** Left anterior oblique (LAO) 45 degrees and Cranial 20 degrees angiographic view showing the LAD artery in diastole (A) and in systole (B). The ECG tracings show at which point of the cardiac cycle the image was taken. Note the change in vessel calibre between the two images.





### Discussion

This case highlights two key points in the process of grafting an intramuscular coronary artery. The first is the pre-operative identification of such an anomaly, which may be missed on angiography. Localised bridging is usually identified with a short segment that takes a deeper course and may exhibit contraction during systole.<sup>15</sup> When the bridging is long and covers an extensive segment of the intramuscular coronary artery the angiographic signs may be subtle. Our case highlights one of the subtle signs on standard coronary angiography, which is the compression of the coronary artery along its intramuscular length during systole. This is also known as the 'milking effect' and is very often missed especially if the recording speed is too low (<25 frames/second).<sup>13</sup> Computed Tomography has been shown to be an excellent method of visualising the intramuscular coronary artery preoperatively, and may be used in cases where this situation is suspected.<sup>16</sup>

The second important topic regards the intraoperative proceedings. Intramuscular coronary arteries are often discovered at operation. Locating and exposing the intramuscular artery is a key step in performing the operation. With short myocardial bridges the coronary artery is usually visible proximal and distal to the buried segment, which may be de-roofed by dividing the muscular fibres. When the entire artery is intramuscular it is only visible as a small vessel at the heart apex.<sup>7</sup> Several alternative techniques have been described. Aydin U. et al utilised intraoperative fluoroscopic identification of the left anterior descending artery using a radio-opaque graded marker on the myocardial surface and an antegrade root injection of contrast via the cardioplegia line.<sup>17</sup> High frequency ultrasound probes were first used to detect coronary arteries embedded in fat in 1986. More recently, linear ultrasound transducers have been put to use in detection of intramyocardial LAD arteries.<sup>18-19</sup> The sterile epicardial ultrasound probe is used on doppler setting to identify the mid-portion of the intramyocardial coronary artery and using a sterile surgical marker a mark is made to guide the incision to expose the artery.<sup>11</sup>

On-table coronary angiography and the use of a specially made radio-opaque marker strip on the surface of the heart has also been described.<sup>17</sup> These techniques all involve imaging and add to the complexity of the operating room setup.

Oz M.C. et al describe a method when the great cardiac vein overlies the anterior descending artery. A deep elastic traction stitch mounted on a blunt needle is placed around both structures and traction is applied to mobilise the artery to the side and superficially, thereby facilitating its dissection.<sup>20</sup> This technique carries the risk of damaging the artery and also entering the right ventricle.

The method we here describe is similar to that outlined by Robinson in 1973 and requires no additional equipment.<sup>21</sup> A small arteriotomy is performed distally, allowing the retrograde insertion of a probe to identify the proximal LAD. Depending on the calibre of the vessel and the proximity to the apex the surgeon may opt to close the arteriotomy or anastomose a graft to this segment, thereby revascularising an important territory distal to the intramuscular segment. This method relies on a rigid probe to identify a proximal portion of LAD and is, in our opinion, easier than relying on imaging techniques. Both our method as well as imaging methods may be used to de-roof a long segment of the buried LAD. However, the risk of entering the right ventricle is increased and we prefer, instead to apply a second, distal graft where indicated.

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