CHAPTER 1

Abnormalities of Coagulation and Obstetric Anaesthesia

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Key points

- Abnormal coagulation is a relative contraindication to regional anaesthesia. The risk of neuraxial haematoma formation must be balanced against the risks of general anaesthesia in an obstetric patient – particularly in an emergency situation.
- A history or family history of abnormal bleeding or bruising should be sought from all women. Those with known haematological disorders require optimisation by haematologists and multidisciplinary management.
- The risks associated with epidural catheter insertion apply equally to catheter removal.
- The management of patients with abnormal coagulation should involve senior clinicians.
- If coagulation abnormalities are present, follow-up must be robust to ensure prompt detection and treatment of complications.
- Published guidelines outline the risks of regional techniques in the presence of specific coagulation abnormalities. Guidance for the use of regional techniques in relation to pharmacological thromboprophylaxis or treatment is available. For those with normal platelet function, regional techniques can be performed with platelets as low as 50×10^9 L^{-1}.

Obstetric anaesthetists are frequently required to evaluate patients with coagulation abnormalities who require analgesia or anaesthesia. The management of these patients should be individualised according to the risks to the individual at that time. In addressing risks, those of general anaesthesia in the non-fasted patient should not be forgotten. It is not unusual for obstetric patients to present unexpectedly and out of hours, so optimisation of coagulation and the formulation of a management plan should be undertaken as early as possible in those with abnormalities of coagulation

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for any reason. There are several guidelines addressing the use of regional techniques in patients with abnormal coagulation. Since there is a shortage of good quality evidence, these are based largely on case reports and consensus of opinion and, perhaps unsurprisingly, vary widely on their recommendations. The experience of diagnostic lumbar puncture in coagulopathic haematology patients undergoing chemotherapy provides a useful source of data for obstetric patients [1]. The Association of Anaesthetists of Great Britain & Ireland (AAGBI), the Obstetric Anaesthetists' Association (OAA) and Regional Anaesthesia UK (RA-UK) have published a useful guideline that will be referred to in this article [2].

What are the risks?

During pregnancy, aortocaval compression can obstruct venous return, causing distension of the venous plexus within the epidural space and the development of venous collaterals. Venous distension is exacerbated during uterine contractions in labour and both epidural needle insertion and catheter placement are therefore not recommended during a contraction. During routine epidural or spinal anaesthesia, accidental puncture of these veins occurs in 1–18% of patients. If the patient is coagulopathic, the risks of needle or catheter trauma resulting in the development of a spinal or epidural haematoma, which can lead to spinal cord compression and permanent neurological damage if untreated, are increased. Such cases are rare in UK practice, most likely because of the caution exercised by clinicians in the use of regional techniques in patients with abnormal coagulation. The overall risk of the development of a clinically evident haematoma is low. The incidence after epidural techniques is estimated to be in the order of 1:150,000 after epidural placement and 1:220,000 after spinal injection in the general population [2]. It is likely that the incidence is even lower in the obstetric population. Vandermeulen et al. [3] reviewed 61 case reports of haematoma after regional techniques: 41 occurred in patients on heparin or those with abnormal haemostasis, but 15 occurred in patients without known coagulation abnormalities. The review suggested that removal of epidural catheters posed an equal risk to insertion [3]. When low-molecular weight heparin (LMWH) was introduced in the US, approximately 60 spinal haematomas were reported in a 5-year period: a much higher incidence than that reported in the UK and Europe at the time. This was thought to be due to the higher doses and more frequent dosing regime used in the US. The American Society of Regional Anesthesia produced guidelines that suggested a reduction in the dosage frequency in line with European practice, and the incidence then decreased. The use of the newer anticoagulant and antiplatelet drugs is still uncommon in the obstetric population.

One potential difficulty in obstetric practice lies in the early identification and management of epidural haematoma. Women are often discharged from hospital within 24–48 h of regional procedures into community settings. Women and their carers must be made aware that increasing numbness or back pain following regional blockade may indicate the development of a neurological emergency requiring early referral. Referral, imaging and surgery should occur within 18 h for a good chance of full return of neurological function. Any patient with known coagulation abnormalities who has a regional technique must be carefully followed up.

General anaesthesia for parturients with abnormal coagulation

The risks of general anaesthesia, especially in the emergency situation, should always be weighed against the risk of spinal haematoma formation, which can have catastrophic effects but is extremely rare. The reports from the Fourth National Audit Project (NAP4) and CEMACE (formerly CEMACH) highlight these risks. The overall risk of death in those having general anaesthesia for caesarean section was quoted in 2007 as being just over 1:25,000. In addition to the risk of hypoxia and pulmonary aspiration, the uterine relaxant effect of volatile anaesthetics increases the risk of obstetric haemorrhage. If practical, significant coagulopathies should be corrected before general anaesthesia to minimise airway bleeding and decrease the risk of significant surgical bleeding.

What are the causes of coagulation abnormalities in obstetric patients?

The physiological changes of pregnancy affect the coagulation and fibrinolytic systems. The levels of many of the clotting factors increase (in particular factors VII, VIII and fibrinogen) and those of anticoagulation factors decrease, causing augmented coagulation and decreased fibrinolysis. Thromboprophylaxis is increasingly being used in those with known risk factors for venous thrombo-embolism, and women with a history of venous thrombo-embolism are treated with higher doses of heparins. The use of LMWHs has decreased the incidence of heparin-induced thrombocytopaenia but, once given, the anticoagulant effects of LMWHs last longer than those of non-fractionated heparin, and are less easily reversed. This may be a problem if labour starts unexpectedly.

Coagulation disorders occurring during pregnancy and those relevant to pregnancy are summarised in Table 1.1.

Table 1.1 Coagulation abnormalities occurring during pregnancy

Clotting factor abnormalities	
Congenital coagulopathies	Von Willebrand's disease
	Haemophilia and specific factor deficiencies
	Rarer factor deficiencies
Specific obstetric-related coagulopathies	Pre-eclampsia
	Placental abruption
	Intra-uterine fetal death
	Amniotic fluid embolus
	Cholestasis
	Dilutional: major obstetric haemorrhage
	Sepsis
General causes	Anticoagulant therapy
	Disseminated intravascular coagulation
	Liver disease
	Vitamin K deficiency
Platelet abnormalities	
Low platelet numbers	Gestational thrombocytopaenia
	Idiopathic thrombocytopaenic purpura
	HELLP syndrome
	Major obstetric haemorrhage
Poor platelet function	HELLP syndrome

Congenital coagulopathies

Von Willebrand's disease

This is the commonest inherited bleeding disorder. It is found in about 1% of the UK population and has autosomal dominant inheritance, although there is a wide spectrum of severity. It is a disorder affecting the von Willebrand factor (vWF), which is a large protein that promotes platelet adhesion and forms part of the factor VIII complex. There are three types of this disease:

Type 1:	Partial deficiency of vWF but the vWF present functions normally. During pregnancy, there is usually a significant increase in vWF, and levels are often up to the normal range in all but the most severe cases.
Type 2:	In this, there is a qualitative defect in vWF and little improvement during pregnancy. In some individuals termed type 2B, there is an associated thrombocytopaenia.
Type 3:	This is a severe bleeding disorder in which there is a complete absence of vWF and decreased levels of factor VIII. It is unaffected by pregnancy.

Patients with von Willebrand's disease have a prolonged bleeding time and normal platelet count, except in type 2B disease. Desmopressin

(DDAVP) and vWF concentrates are given to increase the levels of vWF, and are most effective in Type 1 disease, in which the vWF is structurally normal.

Although vaginal delivery is considered safe if vWF is >40 IU dL^{-1}, if operative delivery is necessary, a level of >50 IU dL^{-1} is recommended. There is little evidence regarding the safe level for the conduct of regional techniques. Postpartum haemorrhage is a particular risk, as the levels of vWF decrease to pre-pregnancy levels within 24 h. Desmopressin must be used with caution and women must be monitored for signs of hyponatraemia. Those with Type 2B disease should not have DDAVP, as platelet count may decrease further.

Regional anaesthesia is usually considered safe in patients with Type 1 disease, as the levels usually increase to normal levels in pregnancy [4]. The epidural catheter should be removed soon after delivery because of the decline in coagulation factor levels. Central neuraxial block is usually not recommended for women with Type 2 and 3 disease.

Haemophilia

Haemophilias A and B are X-linked disorders resulting from deficiencies of factor VIII and factor IX respectively. Females are usually the carriers of this disease, with one affected chromosome. The clotting factor level activity is likely to be around 50% of normal, but a wide range of values has been reported, and 5% of women have surprisingly low levels due to lyonisation. Haemophilia prolongs activated partial thromboplastin time (APTT). Factor levels should be checked at booking and at 28 and 34 weeks' gestation. The levels of factor VIII and vWF often increase significantly during the second trimester, but there is usually no increase in factor IX levels. Optimisation before delivery for those with haemophilia A requires the administration of a combination of factor VIII concentrates, cryoprecipitate and DDAVP. This therapy may only be effective for 6 h. For haemophilia B, factor IX concentrate and fresh frozen plasma are required, as DDAVP has no effect on factor IX levels. There is a theoretical risk of uterine contractions and hyponatraemia with DDAVP therapy. A plasma level >40 IU dL^{-1} (for both factors) is generally regarded as safe for normal vaginal delivery, and a level >50 IU dL^{-1} for caesarean section. If the factor level is <50 IU dL^{-1}, prophylactic factor supplementation is recommended to maintain levels >50 IU dL^{-1} throughout labour and up to 7 days after delivery. After delivery, factor levels decrease rapidly to pre-pregnancy levels, so the risk of delayed postpartum haemorrhage is increased. Antenatal diagnosis in babies at risk can be performed and, if positive or if not performed, the mode of delivery and the use of fetal blood sampling should be carefully considered.

There is little evidence regarding safe factor levels for regional techniques [4]. Consensus opinion suggests that regional anaesthesia should not normally be undertaken when factor levels are <50 IU dL^{-1} and APTT is abnormal. If the patient presents in labour, there may be insufficient time to perform laboratory tests, but levels taken in the third trimester can be referred to. The epidural catheter should be removed soon after delivery because of the rapid decrease in factor levels after delivery.

Acquired coagulopathies

Disseminated intravascular coagulation

This is an acquired coagulopathy resulting from uncontrolled activation of the coagulation system. This leads to a decrease in clotting factors to a level insufficient to stop further bleeding. Causes of disseminated intravascular coagulation in pregnancy include

- **Placental abruption** Significant bleeding may be concealed, with the only indications being severe abdominal pain and signs of increasing fetal distress. Up to 30% of patients develop a coagulopathy. If the suspected abruption is severe enough to cause significant maternal haemodynamic instability or fetal compromise, general anaesthesia is usually indicated. In cases of suspected abruption without obvious compromise, coagulopathy is less likely and regional techniques can often be used without the need to wait for a coagulation screen, depending on the relative balance of risks. In these cases, tests such as thrombo-elastography (TEG) may prove useful.
- **Intrauterine fetal death** There is an increased risk of coagulopathy, especially after the second week following fetal death. Coagulation abnormalities are present in about 3% of women with apparently uncomplicated intrauterine fetal death, and this increases in the presence of abruption or uterine perforation to about 13% [5]. The onset of coagulopathy is variable but can be rapid.
- **Amniotic fluid embolism** In this obstetric emergency, amniotic fluid is released into the maternal circulation. The cause is unknown but the response is thought to involve both the complement system and the immune response. If women survive the initial cardiorespiratory collapse, uterine relaxation and disseminated intravascular coagulation will contribute to severe haemorrhage, which is often difficult to manage. Diagnosis is by exclusion. Uterine atony should be anticipated, and prophylactic use of uterotonics and surgical methods to increase uterine tone should be employed. Cryoprecipitate infusion should be considered at an early stage.
- **Sepsis**

Pre-eclampsia and HELLP syndrome

Pre-eclampsia is associated with low platelet levels. There is increased destruction of platelets resulting from immunological mechanisms. In HELLP (haemolysis, elevated liver enzymes, low platelets) syndrome, platelet numbers decrease rapidly and liver dysfunction contributes further to coagulopathy. In pre-eclampsia, a decreasing platelet count may be associated with abnormal platelet function and other coagulation abnormalities, and the course is often unpredictable.

Liver disease

Any cause of liver disease can be coincidental with pregnancy and result in abnormal coagulation. Specific conditions of concern occurring in the pregnant population include:

- **Acute fatty liver of pregnancy**
- **Cholestasis** In obstetric cholestasis, coagulopathy may develop as a result of decreased absorption of vitamin K, which is required for activation of clotting factors. Bacq et al. showed that 8% of women with cholestasis have a prolonged prothrombin time but some question the importance of checking clotting in all cases [6]. It is important to check coagulation before regional blockade, but changes do not occur rapidly and are responsive to vitamin K treatment.
- **HELLP syndrome**

Platelet abnormalities

- **Gestational thrombocytopaenia** Platelet numbers decrease during normal pregnancy, but in the majority of women they remain $>150 \times 10^9$ L^{-1}, the threshold below which haematologists define thrombocytopaenia. Gestational thrombocytopaenia occurs in 5–8% of pregnant women, usually presenting in the third trimester, but it should only be labelled as such after excluding other causes. The majority have platelet counts between 100 and 150×10^9 L^{-1} but in about 0.5% of women they are below that level. The decrease is thought to be due to a combination of haemodilution and increased destruction. The decrease in platelet numbers is thought to be balanced by enhanced platelet activity during pregnancy, but in clinical practice it is difficult to evaluate this precisely.
- **Idiopathic (autoimmune) thrombocytopenic purpura (ITP)** This is an immunological disorder that commonly occurs in young females. Some patients will become pregnant in the knowledge that they have ITP, and others may be diagnosed in the first trimester. Platelet autoantibodies are present on the platelet membrane and platelets are destroyed in the reticulo-endothelial system. The production of new platelets

does not match the destruction of old platelets and therefore thrombocytopaenia occurs. Platelet counts are usually in the order of 50–75 $\times$ 10^9 L^{-1}. Patients may well have no symptoms but some will have an increased incidence of bruising and epistaxis. There is transplacental transfer of antiplatelet antibodies, so the neonate may develop thrombocytopaenia, which may have implications for the mode of delivery. Treatment aims at increasing platelet count if it decreases to $<50 \times 10^9$ L^{-1}, and high-dose corticosteroids or high-dose intravenous immunoglobulin can be given before regional techniques. Splenectomy may occasionally be required and, if it is, can usually be performed laparoscopically during the second trimester.

Which tests for which patients?

There is no evidence to support routine full blood count (FBC) or coagulation tests in women before the performance of a regional block in those who have had

- normal FBC results;
- no bleeding history;
- no signs or symptoms of liver disease;
- no signs or symptoms of pre-eclampsia, abruption or clinical signs of disseminated intravascular coagulation;
- no recent anticoagulant treatment.

Regional analgesia or anaesthesia should be administered in a timely fashion and not delayed or avoided while awaiting the results of blood tests in these patients.

Full blood count

- In women with known thrombocytopaenia, an FBC should be checked within 24 h.
- In women with mild to moderate pre-eclampsia, the course of the disease can be unpredictable: it is recommended that an FBC be checked within 6 h of a regional procedure. In addition, coagulation tests should be performed if platelets are $<100 \times 10^9$ L^{-1} or if there is abnormal liver function. In women with severe disease, FBC and clotting should be checked immediately before a procedure, as platelet levels in particular can decline rapidly. Women with pregnancy-induced hypertension alone do not require an FBC before a regional procedure.
- Those who have been on heparin for more than 4 days are at risk of thrombocytopaenia.

Activated partial thromboplastin time ratio and international normalised ratio

- Activated partial thromboplastin time ratio (APTTR) and international normalised ratio (INR) are slightly decreased in late pregnancy. The APTTR is a good screening test for deficiencies of factors VIII, IX, XI and XII, and heparin-induced anticoagulation. The INR tests for deficiencies in II, V, VII, X and fibrinogen.
- In women with obstetric cholestasis, coagulation status should be checked within 24 h of a regional procedure, although in practice changes affecting coagulation do not usually occur rapidly.
- In women on heparin (or warfarin), an FBC and APPTR (or INR for those on warfarin) should be checked immediately before anaesthetic or surgical interventions.
- For those on LMWHs, the assessment of anti-Xa levels to determine bleeding risk is controversial, and in practice takes time, rendering it not particularly useful. Although high anti-Xa levels have been shown to be a good predictor of bleeding risk, lower levels have not been shown to be reassuring.

Thromboelastography

- TEG is now providing useful information about overall coagulation status and, importantly, fibrinogen deficiency in haemorrhage, and has the great advantage of being a point-of-care test that provides results within 15 min, thus enabling decisions to be made on the basis of the results in real time. An early decrease in fibrinogen concentration is a predictor of severe postpartum haemorrhage; prompt management can significantly improve outcome. It has been shown that the ability to provide real time, targeted coagulation management can decrease the need for additional blood and products [7].
- The sensitivity and specificity of TEG results in pregnancy and their exact relationship to the risk of any haematoma development is still being evaluated. An abnormal TEG should usually preclude the use of regional techniques.

Guidance for the use of regional anaesthetic techniques in patients given anticoagulant drugs

The use of anticoagulant drugs in pregnant patients poses significant difficulties in balancing the risk of thrombo-embolic disease with that of the formation of an epidural haematoma following neuraxial blockade [8–10].The key issues to be addressed are planning when to stop the anticoagulant, or

Table 1.2 Summary of the recommendations from the AAGBI, the OAA and RA-UK guidelines [2] regarding the performance of regional anaesthesia after anticoagulant therapy

Drugs	Recommendations for neuraxial block
Aspirin and non-steroidal anti-inflammatory drugs	Antiplatelet effect of aspirin persists until new platelets are manufactured (at least 7 days), whereas platelet function returns to normal within 3 days after stopping NSAIDs. Central neuraxial block can be safely performed in patients taking these drugs.
Unfractionated heparin	Delay block for 4 h after subcutaneous dose and give >1h after performing a block. Stop intravenous heparin infusion 4 h before block. APTTR should be checked and be normal. Restart intravenous heparin >1 h after performing a block.
Low-molecular weight heparin	Delay block 12 h after prophylactic LMWH. Give LMWH >2 h after performing a block. Wait for 24 h after a therapeutic dose of LMWH is given before performing a block. If a bloody tap, consider delaying next dose for 24 h

NSAIDs, non-steroidal anti-inflammatory drugs; APTTR, activated partial thromboplastin time ratio; LMWH, low-molecular weight heparin.

how long to wait before a regional technique if the routine administration of the drug has not been stopped, planning when the drug can be restarted after a regional technique, and patient follow-up.

Even though there are few firm data to support recommendations, guidelines have been produced by the American Society of Regional Anesthesia, the European Society of Regional Anaesthesia and a number of European countries. There are many differences between them, reflecting differing drugs and dosage regimes. The guidance published by the AAGBI, the OAA and RA-UK was based on expert opinion, case reports, case series, cohort studies and extrapolations from the drug properties and the known half-lives of drugs [2]. Table 1.2 summarises the recommendations from these guidelines regarding recommended performance of regional anaesthesia in patients taking anticoagulant drugs.

Guidance is just that; the ultimate decision to proceed or not proceed with a regional technique after an anticoagulant has been given outside of the recommended time range depends on the individual relative risks compared to delaying the procedure or abandoning in favour of general anaesthesia. The risk of thrombosis also needs to be considered if a drug is stopped for a significant time if the woman has a prolonged latent phase of labour or postpartum haemorrhage.

Risk assessment for the use of regional techniques in women with coagulation abnormalities

Table 1.3 is drawn from the AAGBI, the OAA and RA-UK guidance, and summarises the continuum of risk in performing regional techniques in obstetric patients [2]. It was designed to encompass the very real need to view decision-making in the light of relative risks to an individual. It also needs to be acknowledged that there should be no definitive cut-offs on the basis of exact numbers, as risk is a continuum from normal risk to very high risk. Exact numerical values of tests will differ to some extent within the limits of normal laboratory error.

Guidance for regional techniques in women with low platelets

The risk of performing neuraxial blockade in women with thrombocytopaenia is guided by case reports, experience from haematological practice and expert consensus opinion. For healthy women with no known obstetric complications, there is considered no increased risk of complications with platelet counts $>100 \times 10^9$ L^{-1} [11]. A count of $>75 \times 10^9$ L^{-1} has been proposed as an adequate level for regional blocks when there are no other risk factors and the count is not decreasing [12]. In pre-eclampsia, a decreasing platelet count may be associated with abnormal platelet function and other coagulation abnormalities, especially when the count is $<100 \times 10^9$ L^{-1}, and a coagulation screen should be performed. If this is normal, it would be reasonable to perform a regional block with platelet counts down to a level of 75×10^9 L^{-1} providing the platelet levels are checked within 6 h of performing the block [13]. The rate of decrease of platelet numbers is very important and, if it is rapid, a sample should be checked immediately before the block.

In ITP and gestational thrombocytopaenia, although there are decreased platelet numbers, the function of these platelets is normal or even enhanced. When the platelet count is $>50 \times 10^9$ L^{-1}, an experienced anaesthetist may be prepared to perform neuraxial blockade, but an individual risk-benefit assessment should be made [1, 12]. It is possible that spinal anaesthesia is safe even when the platelet counts decrease to below this level [1].

Risk of regional techniques in women on LMWHs and aspirin

Daily LMWH and low-dose aspirin are recommended for women with obesity or hypertension. This combination is of greater concern than either drug alone but, provided the LMWH is stopped for >12 h, the platelet count

Table 1.3 Relative risks related to neuraxial blocks in obstetric patients with abnormalities of coagulation

Risk factor	Normal risk	Increased risk	High risk	Very high risk
LMWH – prophylactic dose	>12 h	6–12 h	<6 h	<6 h
LMWH – therapeutic dose	>24 h	12–24 h	6–12 h	
UFH – infusion	Stopped > 4 h and APTTR ≤ 1.4			APTTR above normal range
UFH – prophylactic bolus dose	Last given > 4 h	Last given < 4 h		
NSAID + aspirin	Without LMWH	With LMWH dose 12–24 h	With LMWH dose < 12 h	
Warfarin	INR ≤ 1.4	INR 1.4–1.7	INR 1.7–2.0	INR > 2.0
General anaesthesia	Starved, not in labour, antacids given		Full stomach or in labour	
Pre-eclampsia	Platelets > 100 × $l0^9$ L^{-1} within 6 h of block	Platelets 75–100 × 10^9 L^{-1} (stable) and normal coagulation tests	Platelets 75–100 × 10^9 L^{-1} (decreasing) and normal coagulation tests	Platelets < 75 × 10^9 L^{-1} or abnormal coagulation tests with indices ≥1.5 or HELLP syndrome
Idiopathic thrombocytopenia	Platelets > 75 × 10^9 L^{-1} within 24 h of block	Platelets 50–75 × 10^9 L^{-1}	Platelets 20–50 × 10^9 L^{-1}	Platelets < 20 × 10^9 L^{-1}
Intra-uterine fetal death	FBC and coagulation tests normal within 6 h of block	No clinical problems but no investigation results available		With abruption or overt sepsis
Cholestasis	INR ≤ 1.4 within 24 h	No other clinical problems but no investigation results available		

LMWH, low-molecular weight heparin; UFH, unfractionated heparin; APTTR, activated partial thromboplastin time; NSAID, non-steroidal anti-inflammatory drug; INR, international normalised ratio.
Source: AAGBI, OAA, RA-UK, 2013 [2].

is $>75 \times 10^9$ L^{-1}, and normal coagulation is confirmed, neuraxial blocks can be performed.

Is the seniority of the anaesthetist an issue?

Some guidelines suggest that an experienced anaesthetist should perform regional blocks in patients with known coagulation abnormalities, as the risk of haematoma is higher after a bloody procedure, and the latter is made more likely by a larger number of attempts at needle insertion and catheter placement. However, the potential benefits deriving from a less experienced anaesthetist performing the block might outweigh the risks of delaying while experienced help arrives or abandoning the regional technique and opting for general anaesthesia.

Which technique should be used?

The incidence of haematoma is greater after epidural techniques than after spinal injections. However, when planning the type of regional anaesthesia to be provided, the length of the obstetric procedure must be considered and thereby the risk of converting to a general anaesthetic.

When should epidural catheters be removed?

It is important to ensure that the guidance in Table 1.3 applies to the removal of epidural catheters as well as their insertion. Here, the risks needed to be balanced against those of leaving the catheter in place. Ideally, the epidural catheter should only be removed after a return to normal coagulation status. After major obstetric haemorrhage or HELLP, it may take several days for values to return to normal or acceptable values. The risks of infection, albeit low, delayed mobilisation and wrong-route drug administration also need to be considered.

What follow-up is required?

Guidelines should be in place for the follow-up of all women after neuraxial block [8]:

- Those with known abnormal coagulation need to be monitored closely, and low concentration of local anaesthetics should be used when feasible for analgesic infusions to allow early detection of neurological abnormalities.
- Neurological observations should be performed every 4 h, and continued for at least 24 h after catheter removal.
- If any significant additional sensory or motor defect develops, the epidural should be stopped if still running, and the patient should be monitored for resolution of the signs and symptoms. If this has not occurred

within 4 h, an urgent magnetic resonance imaging scan should be performed.
- Longer follow-up is indicated for those at high or very high risk.
- Patients and midwives should be aware of the signs and symptoms of spinal haematoma, and be aware of rapid referral pathways if complications develop. Surgery on spinal haematoma should ideally be performed within 8–12 h of the identification of symptoms in order to improve the chances of recovery.

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