Treatment of intramedullary nailing complications

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Abstract

Despite great progression in intramedullary fixation of the fractures with many improvements and diminishing the incidence of complications some of them still arise. The most common complication that can occur before the operation, during the procedure and thereafter and their treatment are discussed. The best treatment of them is probably their prevention with being aware of them.

Introduction

Development of intramedullary fixation of long bone fractures has brought about solutions to many complications that may occur when this method is chosen for fracture management. But, like in all methods, problems still arise in intramedullary fixation, too. Being aware of such complications and taking them into consideration all through the treating process allows us to face them most successfully.

Pre-operative complications

Fracture triggers numerous mediators, cascade reactions and processes in the body with the intention to cure the injury in the shortest possible amount of time. Therefore a fracture cannot be looked at and treated only locally. Instead, careful consideration must be taken into account about the patient's general and local condition with reference to the characteristics of the fracture (*personality of fracture*) (1). A fracture can cause drastic changes in existing illnesses and conditions, or it can even occur as a consequence of such conditions (osteoporosis).

Early fixation associated with proper conditioning of the patient influences the development of complications radically. Stabilization of fragments affects the blood loss, blood pressure, pain and nerve structures and other pathophysiological activities and responses in the body. Reduction and stable fixation enable early patient's mobilization, with the influence (avoidance) on cardiovascular, respiratory and urinary system disorders and particularly on bedsores that occur very commonly with the conservative treatment (2). To prevent venous thrombosis, patients are given doses of low-molecular heparins as early as possible after the fracture, according to the protocols to particular low molecular heparins (depending on various values of international units, patient's weight, risk factors etc. and according to the recommendations – generally once a day, 3-6 weeks and up to 3 months in paraplegics) (3).

To prevent intra-operative infections, the patient is given an antibiotic prophylaxis - one-time or 24-hours dose of first or second generation cephalosporins (4, 11). In intramedullary fixation of open fractures (according to Gustilo-Anderson classification in fractures type III (eventually also in type II)) duration is extended for up to 5 days or 24 hours after the soft tissue coverage with the recommendations towards third generation cephalosporins and an anaero-

bic agent like metronidazole or clavulanic acid to prevent development of anaerobic bacteria. When there is a threat of infection with clostridium, penicillin is also given in high dosage. A combination of clindamycin with aminoglycozide can also be used (9). Some other protocols like combinations of cephalosporins and aminoglycozide of various duration were also proposed (1).

Intra-operative complications

Nerve injuries

Excessive pulling or movement of fragments on the extension table can cause nerve injuries (ishiadic, pudendal, femoral, peroneal nerve). These types of injuries are usually treated conservatively (vitamine B, electrostimulation, physical therapy ...) (5).

Reposition

Difficulties can occur during reposition, mostly because of interposition of soft tissues or bone fragments. If closed reposition is not possible, we can make additional incisions and adjust the fragments openly, or we can place additional Schanz screws (joy-stick) into fragments, correct their position under control of an X-ray monitor, or arrange them into a row over the guiding wire or an intramedullary nail. Any interpositioned muscles must be released and never cut through.

Entry point

Incorrect position of the entry-points into the medullary canal can lead to difficulties during reaming of the canal and placement of the intramedullary nail. Parts of the bone (esp. around the entry) can chip off (break), additional fractures or "explosions" can occur, the nail or the locking screws can be placed in an improper position, etc... That is why the entries and the position of the nail and the locking screws must be monitored with an image intensifier during the operation.

In the case of improper position of the nail and insufficient fixation we must correct the nail's position either with the use of the same type of nail or screws, or with a different type of nail (a reconstruction nail instead of a delta reconstruction nail, etc.) to provide sufficient stability of the fracture. The same goes for inefficient fixation because of additional fractures. We can place additional screws, wires or special cerclage wires (instruments), but we must beware of possible injuries that these instruments can cause. Bone and soft tissue circulation can be obstructed, mechanical injuries can occur, soft tissue and surface structures are cut through additional incisions for the placement, etc.

Length and position of fragments

It is very important to find the proper length and position of the extremity and the fragments that need fixation. The length and the position of the healthy extremity must be examined before surgery. Reposition can be easier when monitored with an X-ray monitor and if we follow certain recommendations (observe certain signs). For example - we can compare the position of the lesser trochanter (size and shapes from a certain angle and position and in comparison to the uninjured side) *(lesser trochanter sign)*, if we measure the cortical thickness and it's continu-

ity after reduction *(cortical diameter sign and cortical step sign)*, if we measure the bone diameter at a certain level etc. (6). All this can usually help us achieve the correct length and position of the extremity. Eventual errors in rotation, which are the most disturbing for patients and should therefore be given special attention, can be controlled by imagining a plane connecting *spina iliaka anterior*, the centre of the patella and the big toe, and by examining the position of the condyles on the X-ray pictures during and after the fixation. Comparing joint flexibility on the injured and on the healthy extremity can also help (6). The correct position of the fixated fragments must always be achieved before the patient leaves the operation room. We can correct any irregularities immediately by loosening the locking screws, reposition and refixation of the nail through new openings.

Patient's general condition

Intra-operative co-operation between the surgeon and the anesthesiologist can help us detect any complications that may occur during the operation (fat embolism, pulmonary embolism, sepsis, bleeding, etc.), as they affect the patient's general condition. The following passages describe how to deal with these complications.

Post-operative complications

Compartment syndrome

The ***compartment syndrome*** can occur anywhere in the body where spaces are divided into compartments. It is most common in tibial fractures, but it also occurs on the foot, on the arm, on the thigh, in the gluteal area, and inside the abdomen (7). If the compartment syndrome develops before the operation, the fracture is usually stabilized with an external fixator, associated necessarily with fasciotomy. External fixator is replaced by an internal one when the patient's condition allows this conversion. Special devices are available for measuring the pressures in muscle compartments. They allow individual measuring (with a needle) or continuous measuring (conducted into the compartment through a catheter). Unfortunately, this type of measuring is rarely in use because of its inaccuracy despite the possibility of dynamic measuring.

Pressures in the compartments that are lower than 30 mm Hg normally don't call for fasciotomy. Pressures between 30 and 40 mm Hg require special attention, we often decide to perform fasciotomy. Pressures above 40 mm Hg require immediate fasciotomy of all compartments (8). After the pressures have returned to normal values, we close the fasciotomy areas. Direct sewing is often not enough, so we place special stitches or cover the areas with available skin transplants. Muscular ruptures that might have occured can be reconstructed after the fracture heals.

Infections

Infections are the most common post-operative complication. The risk of infection is increased when the patient is suffering from other illnesses, after late fixation, excessive reaming of the intramedullary canal, and in open fractures where soft tissues are severely injured. The infection rate in open (Gustilo-Anderson) level I fractures is 0-2%, 2-7% in open level II fractures, and over 10% (10-50%) in open level III fractures (8). The location of the fracture and the quality of surrounding soft tissues are very important. The infection rate in open tibial fractures is a

lot higher than in open femoral fractures (4, 7, 8). Modern intramedullary nails with minimal reaming allow safe treatment of open level I, level II and even III-A fractures, special attention is given to soft tissues and antibiotic prophylaxis. We must not forget here that reaming reduces blood circulation, especially in comminuted fractures, and therefore increases the risk of necrosis and infection. In such cases, reaming through the comminuted areas should be avoided (we only ream proximally or distally from those areas).

We must differentiate *superficial* from *deep* infections. Superficial infection is usually handled simply by loosening of the stitches and sometimes (minimal) opening of the wound (not to expose bone or material). If the infection starts to spread, we send tissue samples for microbiological testing, and we prescribe antibiotic treatment. Empirically prescribed antibiotics are later replaced by parenteal antibiotics according to the results of the microbiological tests. The most common empirically prescribed antibiotics are first generation cephalosporins (4, 9), as most infections are caused by Staphylococcus aureus.

If the infection is deep, the stability of fixation and the extent of healing of the fracture play a very important role in deciding on the treatment strategy (10). If the fracture is stable and not healed, we perform thorough washing, necrectomy; we take bioptic samples and thoroughly clean the area. Continuous perfusion (irrigation) is more and more replaced with everyday's (every second day) washing and debridement of the wound under general anaesthesia as long as necessary. The patient is always initially prescribed empirical antibiotic therapy that is replaced with parenteral antibiotics depending on the cause of infection, which is determined with microbiological tests of the tissues. If the fixation is unstable and deep infection is present, the intramedullary nail must be temporarily removed and replaced with an external fixator. The process of debridement, taking samples for microbiological tests and gradual cleaning are the same as above. Empirical antibiotic therapy usually involves clindamycin and additionally quinolone or aminoglycoside or sometimes even third generation cephalosporines (9).

If the bone is also infected and the fracture has not yet been healed, we must remove the nail, perform external fixation, and evaluate the bone vitality. Other required measures are described above. An infected healed fracture is treated as followed: we remove the intramedullary nail, distally open and ream the medullary canal, take tissue samples and send them for microbiological analysis, and we treat the patient with parenteral antibiotics. If the patient's local and general conditions allow it, an infected non-union with insufficient fixation of fragments can be treated by removing the nail, opening the canal distally and reaming it, then it has to be thoroughly washed. This is followed by placement of a stronger nail, and finally by setting a brief drainage (it is not necessary) and parenteral antibiotic therapy. This method of treatment is inefficient in cases of bone defect and when numerous antibiotic-resistant bacteria are present. In those cases, the intramedullary nail must be removed and replaced by an external fixator (10).

In cases of infected pseudoarthrosis, reaming and placement of a stronger intramedullary nail are not enough to assure successful reparation. In such cases, the revision of the fracture should be followed by corticotomy and transplantation of spongious bone tissue (10). When a deep – bone infection is present during the healing process, we remove the intramedullary nail after union, ream the canal and clean it thoroughly (10).

The condition of the soft tissues above the area of fracture or infection is very important. For example, a good soft tissue cover and the thick cortex of the femur allow a more aggressive

approach with more substantial reaming and removal of infected tissues, and placement of a thicker nail. On the contrary, such approach cannot be used on the tibia. Reaming helps remove the infected parts of the bone and accelerates circulation, which results in faster healing and faster "arrival" of antibiotics to the infected area. Systemic parenteral antibiotic therapy of bone infection must last for a longer period of time. Acute osteomyelitis is treated for 6 weeks; chronical osteomyelitis should be treated for at least 12 weeks or at least an additional month after the infectious parameters have returned to their natural state or values (4, 9). Here, the nail is removed after the fracture has healed, we ream the intramedullary canal, take tissue samples for analysis and we thoroughly clean the medullary canal (10).

If systemic signs of infection (septic condition) occur, we must remove the intramedullary nail, and thoroughly clean the intramedullary canal. If the fracture is not stable yet at this point, we perform external fixation. Antibiotic and other necessary treatment are required.

We can also perform laboratory blood tests to detect and treat infections. The least accurate indicator of infection is sedimentation. We can also observe the C-reactive protein (CRP), a very good indicator of bacterial infection (in comparison to virus infection) is procalcitonin (4). Special attention should be given to the trend of increase or decrease, and not to the absolute values. To detect infections, we can carry out scintigraphy (marked leukocytes), classical X-ray tomograms, CT or MRI tests, angiography is often done (esp. when the soft tissue envelope is threatened or when reconstruction is required).

Hemathoma

After surgery, especially in closed reposition and reaming, ***hemathomas*** can occur. If any signs of fluctuation are present, we must remove the hemathomas or drain them, because they present the perfect environment for an infection to develop in (1, 2). The best way to prevent this is with suction drainage at the entries into the intramedullary canal, but we must be careful not to penetrate into the medullary canal because we might "suck out" a lot of blood. Some nails have special openings and screws to block the medullary canal and therefore prevent this complication.

Problems in healing

The use of modern locking intramedullary nails results in primary healing in 95-99% (6). If the fracture does not heal in 4-6 months, we are dealing with a ***delayed union***, after 6-8 months it is called a ***non-union*** (*pseudoarthrosis*) (11). We differentiate between an atrophic and a hyperthrophic non-union. The first form of non-union is usually caused by ischemia or infection, whereas the second occurs because of mechanic instability, which can be a consequence of instable fixation or a broken implant (IM nail, locking screws...). What usually causes the implant to break is early burdening. Nails rarely break, whereas locking screws are more likely to break if the postoperative weightbearing instructions are not followed. Treatment of non-unions must be etiologic. Reaming of the intramedullary canal and placement of a thicker intramedullary nail with locking screws provide the strongest biomechanical stability of the fixation nowadays. Removing the non-vital parts of the bone, reaming the IM canal and placement of a thicker IM nail associated with decortication and mechanical stabilization normally result in bone reparation. We must take tissue samples for microbiological tests during the operation. If the results are positive, we must include specific antibiotic treatment (for 6-12 weeks as descri-

bed above). If we detect an undisputed infection during surgery, we handle it according to the instructions above, in the passage about treatment of an infected pseudoarthrosis.

In the early period, we can achieve successful healing with dynamization of the intramedullary nail – we remove the locking screws at the side where they are further away from the fracture. Removal of the locking screws in the early post-operative period results in rotational problems in approximately 10% of cases; therefore this is not a routine method (12).

If ***bone defect*** up to 2 cm remains after the removal of non-vital parts, successful healing is achieved by transplantation of spongious bone tissue. Larger bone defects require either distraction – bone transport – or transplantation of parts of the bone (vascular fibular graft, for example). Bone transport allows us to safely lengthen the bone for up to 15% of its original length (13). We can do this by shortening it first and then lengthening it, which is useful in fractures with associated vast soft tissue injuries, or with the technique of traction segments without altering the length of the extremity (soft tissues) (1, 2, 11). Bone transport can be performed over nails or with the help of an external fixator (type Ilizarov or modular type). Techniques combining the use of nails and an external fixator have also been described already, but are not routinely performed because of the complications that they can lead to (infection).

Cases of ***malunions*** (incorrect healing) are treated with corrective surgical procedures. The goal must be to achieve ideal position and length of the operated extremity. The errors that bother the patient the most occur in rotation of the leg. Acceptable axes deviations are: less than 5° in varus or valgus, less than 10° in retro- or antecurvation, less than 1 cm in length and less than 5° in longitudinal axes irregularity (8). All other irregularities beyond these recommended values require corrective surgical treatment – biomechanically most acceptable are osteotomy, decortication, spongioplastic, and intramedullary nails.

Heterotopic ossification can occur at the entry of the nail into the intramedullary canal. This occurs in about 25% of cases. The most likely causes are muscle injuries caused during reaming or bone particles that were pressed into the muscle tissue (1, 2). The change rarely causes clinically relevant problems. If difficulties do occur, we remove the bone tissue along with the intramedullary nail (not sooner than 1 year after the operation). Recommended (but not proved) preventive methods include non-steroidal anti-inflammatory drugs (Indomethacin) and radiation (8).

Thrombembolism

In injuries (muscle injuries, bone fractures ...) ***thrombembolism*** can occur. Even though the complication is quite often (in up to 50% of cases), a lot of those events go on clinically silent (8). The risk of pulmonary embolism in those injuries is 1%. Important risk factors are age over 40 years, weight, multiple injuries, spinal and pelvis injuries, immobilization, malignant tumors, and preliminary thrombembolism (8). Thrombembolism normally occurs during the first post-operative week. Clinical signs of deep vein thrombosis, such as pain, swelling or fever, are evident in less than 10% of patients with proximal vein thrombosis. Clinical signs of pulmonary embolism – chest pain, tachycardia, etc. – are also not typical. EKG changes are found in 40% of cases, changes in ventilation and perfusion scintigraphy are accurate in 15-85% (8). The most precise test for discovering pulmonary embolism is (CT) pulmonary arteriography. D-dimer tests and doppler vein analysis tests are used to confirm the diagnosis of vein thrombosis. Invasive contrast venography is the method of choice (8).

When the patient is diagnosed with deep vein thrombosis (embolism), he must be given a bolus of 5000 IE heparin as soon as possible and then an infusion of heparin 1250-1300 IE per hour. Then peroral anticoagulants (coumarins) are included in therapy. We must monitor the number of thrombocytes regularly (heparin immune thrombocytopenia occurs in 3-5% of patients), and pay attention to possible bleeding (in 2-7% of patients) (14). An important consequence of long-term heparin treatment is the development of osteoporosis. Heparin treatment must be associated with coumarins for at least 5 days. The heparin treatment is held when the INR is above 2,0 for two consequent days (14). Nowadays, standard heparin is substituted almost always with low-molecular heparins in therapeutical doses, which are normally injected twice a day under the skin. This way long-term infusion is not necessary. We must only control the level of thrombocytes, the use of low-molecular heparins reduces the risk of thrombocytopenia, bleeding and osteoporosis (14). In the next step, peroral anticoagulants (coumarines) are included into therapy as in treatment with standard heparin (14).

Pulmonary embolism can occur in various clinical forms – from clinically silent forms to severe shock conditions and massive pulmonary embolism. Signs of general affection and lower pO_2 values in the blood call for support therapy (respiratory support), in cases of shock and organ failure we have to introduce all suitable forms of (supportive) therapy in all organ systems. Untreated proximal vein thrombosis is a threatening illness that leads to pulmonary embolism in almost 50% of patients, of which 10% result in death (3). Thrombolitic and surgical treatment or vein thrombosis or pulmonary embolism (removal of clots) is rarely indicated, but it does allow survival in patients with massive pulmonary embolism (14). Peroral treatment with anti-coagulants after diagnosis of proximal vein thrombosis or pulmonary embolism is then continued with consideration to the risk of thrombosis or bleeding for another 3 or 6 months, or patients continue with long-term treatment (15).

Fat embolism

Fractures can also be associated with ***fat embolism***, which is more likely to occur in long bone fractures, in young patients and in patients that have been hypovolemic for a longer period of time with low-energy injuries with multiple fractures and pulmonary damage. Pathogenesis is not yet completely known, but theories are leaning more and more towards cascade mediatory reactions and development of systemic inflammatory reaction (*SIRS – Systemic Inflammatory Response Syndrome*) (2, 6, 8). It occurs in up to 22% of cases of conservative treatment with traction and casting in poly-traumatized patients, and in up to 4.5% in operative treatment (2).

The most important symptoms that occur within 12-72 hours after the injury are heavy breathing, confusion, disorientation deepening into coma, fever, tachycardia, and petechial bleeding in the chest, neck and conjunctives (2, 8). Fat embolism can be best avoided with immediate fracture fixation, good oxygenation and sustained blood pressure (infusions). When it occurs, treatment is supportive, aiming at improving oxygenation, whereas other treatment methods (ethanol, heparin, corticosteroids, etc.) have not given satisfying results in research yet (2, 8).

Mechanical complications

Intramedullary nailing can also lead to ***mechanical complications*** with the nail or the locking screws. They can irritate superficial tissues, they can bend or even break, which is more often

to happen with the locking screws. We usually remove the broken screws by enlarging the opening and pulling them out or by unscrewing them, or we can bounce it out and pull it out at the other side. The intramedullary nail is most likely to break at the openings for the locking screws. After removing the screws, we can remove the nail by placing the guiding wire with the thickened end through the nail and then a few straight wires. Then we pull the thickened guiding wire backwards, which causes other wires to re-arrange like in an umbrella, as the thickened end of the wire gets stuck among them. Then we pull the wire out and by that remove the broken nail. We can also remove the nail with a special wire with a hook at the end. We recommend simultaneous removal of both parts of the broken nail. If we decide to remove the upper part first, we then have to ream the upper part of the medullary canal for additional 2 mm so that the bottom part of the nail does not get stuck while being removed.

Conclusion

The best way to avoid complications is by bearing in mind possibilities for their occurrence and by following instruction to avoid them. If complications do occur, it is important to deal with them immediately, because one complication can lead to another, which significantly reduces the quality of treatment or even threaten the patient's life.

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