Editorial Comments

Crush recommendations: a step forward in disaster nephrology

R. Vanholder¹ and M.S. Sever²

¹Nephrology Section, University Hospital, Ghent, Belgium and ²Department of Nephrology, Istanbul School of Medicine, Istanbul, Turkey

Correspondence and offprint requests to: R. Vanholder; E-mail: raymond.vanholder@ugent.be

Introduction

In a supplement of Nephrology Dialysis and Transplantation, appearing simultaneously with the present issue, recommendations for the prevention and treatment of crush syndrome are published [1]. This monograph contains 85 recommendations, 23 tables, 9 figures and 376 references. Prepared by a workgroup of nephrologists, intensivists, surgeons and logisticians, they emanated out of a joint effort of European Renal Best Practice (ERBP) [2] and the Renal Disaster Relief Task Force of the International Society of Nephrology (RDRTF/ISN).

Crush is a condition which carries a high risk of morbidity and mortality [3, 4]. The number of earthquakes necessitating nephrologic intervention because of crush is steadily growing [5–11]. Next to poor quality of buildings and overpopulation in endangered areas, this evolution can also be attributed to improved rescue and higher awareness of the renal complications of crush, the latter being brought about in part by interventions of specific nephrologic intervention teams. RDRTF/ISN, the first nephrologic relief organization [12, 13], embedded its rescuers in specialized non-nephrologic teams (belonging to Médecins sans Frontières – MSF) enabling backing in areas where (para-)medical personnel lacks know-how, such as logistic support.

In spite of many saved lives, the consecutive interventions also revealed several weaknesses open to improvement. First, the medical expertise of the few practiced renal rescuers could insufficiently be disseminated over the many individual medical professionals taking care of crush patients. This shortcoming applied to diffusion of knowledge to nephrologists, most of whom have low exposure to crush in everyday practice. In addition, however, it also concerned other specialists or generalists who have limited experience with Acute Kidney Injury (AKI). Second, the existence and contact coordinates of renal relief teams remained often unknown to other relief organizations or to local specialists who after earthquakes coincidentally got involved in treatment of crushed victims without being prepared.

The crush recommendations which are commented in this editorial hopefully cope with these problems, forwarding a structured approach to treat crush and associated conditions.

General contents

The text, which targets also non-nephrologists, adheres to the sequence of phases a victim traverses (Figure 1): approaches before, during and after extrication, in the field, during transport, at admission and during stay in the hospital (prevention, conservative and dialysis treatment). Finally, logistic organization, advance planning and implementation are covered.

In what follows, we summarized nine prominent topics: fluid administration, hyperkalaemia, hypocalcaemia, acidosis, fasciotomy, amputation, dialysis, planning and logistic organization. We refer to the corresponding recommendations and tables between square brackets [ ].

This editorial does not replace the proper recommendations, which are more comprehensive, offer in depth therapeutic instructions and contain structured guidance rules together with their rationale. The interested reader is therefore referred to the full publication [1].

Fluid administration

While an equilibrated fluid status and an adequate perfusion of the kidneys are essential for all imminent cases of AKI, intravascular hydration is even more imperative in rhabdomyolysis and crush, due to the preferential sequestration of large quantities of fluid in the injured muscles [14, 15]. Together with direct toxic effects of myoglobin and intra-tubular obstruction due to deposition of myoglobin and uric acid, this dehydration is the main cause of AKI. Hence, the cornerstone of prevention of AKI in crush is the timely administration of large quantities of appropriate fluid. Main points of attention are timing, quantity and fluid composition.
Fluid resuscitation should be unequivocally started when the victim is still under the rubble [II.3.D], or, if this appears impossible, during [II.4.A] or immediately after extrication [16] [II.6.A].

The quantity to be administered depends on several factors. During extrication, a flow of 1L/h is recommended during the first 2 hours, then 0.5L/h [II.3.D; II.4.A]. After extrication, if the patient did not yet receive fluid, 1L/h is recommended as starting dose as soon as possible [II.6.B] while in total 3-6 L should be given over a period of 6 hours [II.6.B] (Fig. 2). The subsequent fluid administration depends on the urinary response. In case of sustained anuria after exclusion of hypovolaemia, the recommended volume is restricted to 500 – 1000 mL/day plus the equivalent of all measured or estimated fluid losses of the previous day [II.6.D]. In case of urinary response, the subsequent approach depends on the monitoring possibilities. In restricted disasters, early and persistent administration of large quantities of fluid (> 20 L/d) have shown marked benefit [17], but smaller quantities (~6L/d) are to be applied if close monitoring is unlikely in chaotic mass disasters [9] [II.6.E]; furthermore, fluid flux should be adapted depending on age (less in older victims); body weight (less in lighter patients); trauma pattern (less if affected muscle mass is small); ambient temperatures (less with cold climate); and urinary volume (less in oligo-anuria) [II.6.E].

The recommendations concerning the composition of the fluids are based on patho-physiological knowledge, literature data, and practical considerations. Isotonic saline is considered the first choice [II.3.D; II.4.A; II.6.A; II.6.B] because of its easy availability while taking into account that the quantity of fluid and the rapidity with which administration is started are more important than composition per se.
An alternative to isotonic saline is half isotonic saline supplemented with sodium bicarbonate [Table 3]. Bicarbonate, by alkalizing the urine, prevents tubular deposition of myoglobin [14;18], and is a therapeutic asset against hyperkalaemia [III.2.D] and acidosis [V.2.B.3], two common disturbances in crush (see below). However, alkaline solution was considered second choice for mass disasters, because of its lower availability and the potential difficulties in preparation, especially in chaotic conditions. It is, however, considered a valid option, especially in more isolated rhabdomyolysis cases where close monitoring is possible.

No recommendation is devoted to mannitol solutions, but their use is discussed in the rationale. Whereas the diuretic and anti-oxidant properties of mannitol, offering the potential to desobstruct the tubule and remove myoglobin casts [19], are recognized, the compound is on the other hand also considered nephrotoxic and having the capacity to induce fluid overload and cardiac congestion [20]. Literature reports on its efficacy in crush are not consistently favourable [21]. Mannitol is explicitly discouraged in anuria if urine flow does not resume after a test dose (60 mL at 20% over 3-5 min).

Hyperkalaemia remains one of the main killers in crush [22], especially by causing arrhythmia and cardiac standstill. Muscle devastation, causing massive release of intracellular contents into the blood stream, results in dramatic increases in serum potassium, which is further enhanced by acidosis and loss of kidney function [14]. In addition, hyperkalaemia is synergistic with hypocalcaemia, another frequent biochemical disturbance in crush (see below). Their negative inotropic and arrhythmogenic impact on the heart increase the risk of renal hypoperfusion and thus of AKI.

To cope with hyperkalaemia, several preventive and therapeutic measures are recommended:

- The need for diagnosis and treatment as early as possible [II.7.B; III.2.D]. In field circumstances, a point-of-care device is useful for quick diagnosis [7, 8] [III.2.C]. If no such device is available, ECG may be an alternative; however there is a risk for false positives and negatives.
- Several therapeutic options act immediately (Ca Gluconate, β-agonists, bicarbonate, glucose-insulin); they are, however, not definitive, as most of them only cause a relocation from plasma to intracellular and/or are short-acting. The so-called second-line options (polystyrene – kayexalate, or dialysis) may take more time to decrease potassium but cause real and persistent removal [III.2.D; V.3.C]. Of note, dialysis is by far the most efficient and definitive tool to cope with hyperkalaemia. Here, the time loss is rather due to the need to create a vascular access and to prepare the dialysis machine technically than to the intervention per se.
- The application of infusion fluids containing even small amounts of potassium like Ringer’s lactate is strongly discouraged.

Hypocalcaemia

Next to hyperkalaemia, the most important electrolyte disturbance is hypocalcaemia, resulting from the influx of calcium into the muscle due to functional impairment of the muscular cell membrane; it may result in paraesthesia, tetany, seizures, hypotension, bradycardia, impaired cardiac contractility and arrhythmia. The calcium accumulated in the muscles is released back into circulation at a later stage when the muscular lesions are healing, hence creating at that time a potential for hypercalcemia. Therefore, in crush, correction of hypocalcaemia is recommended only if it is symptomatic [III.2.H].

Acidosis causes dysfunction of a host of organ systems and enhances hyperkalaemia. The recommendations advise correction only from a pH below 7.1 on [III.2.H; V.2.B.3] since bicarbonate treatment can induce electrolyte disturbances by itself. In case of severe hyperkalaemia, alkalization of plasma may help in obtaining a quick decrease in serum potassium levels [III.2.D]. Dialysis is an option to correct acidosis without inducing unphysiologic shifts of other electrolytes (see below).

Fasciotomy and amputation

Fasciotomy and amputation remain frequently applied in crushed disaster victims, but are not always performed according to strict standards and criteria. Fasciotomy is associated with a high rate of potentially life-threatening complications such as sepsis, which in its turn is a major cause of mortality in this situation [23, 24]. Amputations are directly associated with mortality [23]. Therefore, the recommendations contain specific advice regarding:

- The need to decide for fasciotomy on objective criteria such as a markedly increased intracompartmental pressure or absent pulsations of peripheral vessels [IV.1.A].
- The discouragement of routine fasciotomy only to prevent compartment syndrome [IV.1.A].
- The necessity to amputate if a limb jeopardizes a patient’s life, rather than desperately trying to conserve the extremity [IV.2.A].
- The need to have the amputations performed early, if indicated [IV.2.C].
- The formal discouragement of amputations only to prevent crush syndrome.

Renal replacement therapy

In the aftermath of earthquakes, the needs for dialysis are substantial [5–10, 25]. All dialysis strategies (intermittent haemodialysis, continuous renal replacement therapy – CRRT, and peritoneal dialysis – PD) have specific advantages and disadvantages [Table 12]. Intermittent haemodialysis is preferable because it enables the treatment of several victims at the same position, while allowing a
vigorous removal of potassium in case of hyperkalaemia and minimal anticoagulation in heavily traumatized or operated patients [25, 26] [V.3.D]. Dialysis should be started timely [V.3.C], especially in case of electrolyte (hyperkalaemia), acid-base or fluid disturbances [V.3.A].

Planning and logistic organization

The opening and the final part contain advice on organizing and planning rescue support, both for the individual and for the community. Advance planning is a cornerstone of any relief operation [27].

Candidate rescuers should be informed beforehand about the location, type, and extent of interventions possible after a disaster and should have a definite idea about their future role [II.2]. An essential but often neglected aspect is that rescuers before going into action should check whether the condition of their family, property and surroundings is under control [II.1]. Medical professionals should ensure their own safety and not take directly part in extrication activities [II.3.A].

Nephrologists, regional authorities and national governments should make advance plans of who will play what role at what place [VIII.1]. Also storage and distribution of materials and allocation of incoming external personnel should be planned carefully and adapted ad hoc along the needs [VII.1; VII.2; VII.3].

Although the main nephrologic concern with earthquakes is AKI, chronic dialysis patients may develop problems as well, especially if their dialysis unit is damaged [28]. The recommendations include instructions on how preparing chronic dialysis patients in earthquake-prone areas, including:

- Instructions to the patients on how to handle the dialyser tubing and vascular access if there is a need to evacuate the unit suddenly [VIII.1.D].
- A definite advance planning on patient relocation for if a dialysis unit is damaged [VII.3.D].
- Instructions on how to react as a patient if dialysis possibilities are lacking, or if the full number of sessions per week cannot be accomplished, e.g. which dietary and other measures to take [VIII.1.D].

At several disasters, it appeared that local medical communities in earthquake-prone areas were not well prepared [11]. We hope that the recommendations commented here will give a boost to authorities to activate advance planning. Nephrologists from earthquake-prone countries and their National Societies should take the lead and convince their authorities of the importance of these preparatory actions.

Conclusions - the future

Although the contents of the recommendation under discussion may also apply to non-disaster crush, it should be taken into account that our guidance is not specifically intended for this condition, as it essentially focuses on crush syndrome in mass disasters. We are confident that they will offer critical support and advice to any (para-)medical professional who is confronted with crush patients in these dramatic circumstances.