Renal Allograft Compartment Syndrome: Is It Possible to Prevent?

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ABSTRACT

Renal allograft compartment syndrome (RACS) is a complication characterized by increased pressure over 15 to 20 mm Hg of the iliac fossa site of transplanted kidney that can lead to a reduction of the blood supply to the graft, resulting in organ ischemia. This study aims to evaluate, through a review of the literature, the incidence, detection, treatment, and possible prevention of RACS. The incidence of this complication, which appears generally in the immediate post-transplantation period, is currently approximately 1% to 2% and is underestimated because of poor nosography for the presence of symptoms common to other post-transplantation complications. Doppler ultrasound is indispensable to evaluate the graft function in the immediate postoperative period and in the following days. The onset of RACS involves a surgical decompression of the graft and the subsequent closure of the abdominal wall with tension-free technique. Several authors agree that only the immediate surgical decompression following an early diagnosis can ensure a recovery of the graft. Early detection of the RACS is the key to preventing the loss of the graft. It is desirable to prevent this syndrome by reducing the discrepancy in weight between donor and recipient by 17%. However the shortage of organs makes such a selection not easy; therefore, in cases at risk for RACS, a close instrumental and clinical monitoring of the patient during post-transplantation recovery is recommended, so a prompt surgical decompression can be performed if RACS is suspected.

RENAL ALLOGRAFT COMPARTMENT SYNDROME (RACS) is an early complication following kidney transplantation. In the absence of prompt treatment, it can have devastating effects, including the loss of the graft. If the transplanted kidney is too big for the size of the shallow false pelvis and the limited retroperitoneal space, increased pressure will be transmitted to the graft and causing graft ischemia with reduction of renal function (by 25% with an increased pressure between 15 and 20 mm Hg, and the onset of anuria when the pressure is higher than 20 mm Hg) [1].

The identification of RACS as a clinical entity is very recent [2]; the diagnosis was made for the first time thanks to the definition of abdominal compartment syndrome (ACS), a life-threatening condition characterized by a rapid and sudden increase of intra-abdominal pressure that may arise from abdominal trauma (blunt or penetrating) or non-traumatic conditions such as septic peritonitis, intestinal obstruction/perforation, acute pancreatitis, acute cholecystitis, aortic aneurysm rupture, mesenteric infarction, and organ transplantation. The increase in intra-abdominal pressure due to cytokine release, formation of oxygen free radicals, decreased cellular energy production, edema, hypoperfusion, and ischemia can cause rapid deterioration of clinical condition up to multiorgan failure [3,4].

The identification of RACS was observed in renal transplant recipients who had a sudden reduction and/or loss of function of the graft not attributable to either pharmacological or immunological complications [5–8].

The World Society of Abdominal Compartment Syndrome (WSACS) released a classification for intra-abdominal hypertension [9] (Table 1). ACS is defined as a sustained intra-abdominal pression greater than 20 mm Hg that is

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Table 1. The World Society of Abdominal Compartment Syndrome Grade Classification for Intra-abdominal Hypertension

Intra-abdominal hypertension	Prolonged or repeated elevation of IAP >12 mm Hg
Grade I	12–15 mm Hg
Grade II	16–20 mm Hg
Grade III	21–25 mm Hg
Grade IV	>25 mm Hg

associated with new organ dysfunction/failure. In consideration of a possible increase of intra-abdominal pressure >20 mm Hg, abdominal compartment syndrome should be suspected in order to implement therapeutic methods to timely prevent or cure the onset of complications that would lead to the loss of the graft in transplant recipients.

The recognition of this syndrome in recent years as clinical condition has allowed the recovery of transplanted kidneys that in the past had been lost and for which clinical deterioration was mistakenly attributed to immunological, pharmacological, and/or iatrogenic causes.

Clinical Presentation of RACS

RACS immediately post-transplantation, which was described for the first time by Humar et al in 1996 [2], has an incidence of 1% to 2%. However, the data still may be underestimated because of misunderstanding regarding this syndrome; in fact, the symptoms are common to other complications after transplantation (acute tubular necrosis, hyperacute rejection, acute rejection, thrombosis of renal vessels). Commonly, the patient presents with general discomfort, tense abdomen, tachypnea, oliguria, and hypotension [10–13]. There are no characteristic clinical signs indicative of abdominal compartment syndrome. It is assumed that the raised pressure exerted on the transplanted kidney increases the intracapsular pressure, vascular resistance, and the inversion of the wave diastolic flow in the renal artery, thus reducing the blood supply to the graft, with the consequent reduction or loss of function. This hypothesis was supported by experimental studies carried out [14] on transplanted mice by Herrler et al, in which the ischemia-reperfusion injury that raises of intracapsular pressure and decreases renal flow and tubular function can be resolved through a polar capsulotomy of the kidney [15].

Identification of RACS

Early diagnosis is a critical step to avoid the loss of the graft in the immediate post-transplantation period. Nowadays the identification of patients at risk of RACS is still difficult. However, some progress has been made since some categories of people have been identified who may be considered at higher risk of developing the syndrome because of the significant discrepancy in weight compared to the donors (the pediatric recipients of adult donors) [12,16]. Also at higher risk are patients undergoing closure of the muscular wall of the abdomen with a non−tension-sparing

technique [13]. In fact, in a study of 538 patients, Ortiz et al have found as statistically significant risk factors for the development of RACS the length and the width of the transplanted kidney with an odd ratio of 1.61 and 2.32, respectively, whereas the body mass index of recipient, vascular anomalies, the incision site, and the site of placement of the graft were not statistically significant [17]. Finally, being that RACS is a variant of the ACS, conditions such as lymphocele, ascites, the preoperative intestinal edema associated with hypoalbuminemia, and the quantity of liquid introduced during anesthesia may be considered other risk factors [18,19].

To date there is no standardized protocol for diagnosing RACS: some authors have proposed measuring intraoperative intra-bladder pressure in pediatric recipients to indirectly estimate intra-abdominal pressure [10]. Several studies point to the role of a Doppler ultrasound (US) of the renal vessels [15,20–22] to identify possible impairment of blood flow, not only in the immediate postoperative period but also in the days that follow. Thanks to the fact that this control is easy to use, inexpensive, noninvasive, and repeatable, it is today the most widely used diagnostic method for monitoring the transplanted kidney. Doppler US scan identifies all those alterations of flow that can be connected with a probable onset of RACS. However, if the reversal of diastolic flow in the intrarenal arteries occurs or there is an absence of flow in renal veins, this may indicate the onset of abdominal compartment syndrome, or other conditions such as acute tubular necrosis or vascular renal thrombosis. In a study of 575 transplanted patients, Horrow et al [20] analyzed the main US vascular abnormalities in the immediate post-transplantation period: the anomalies considered were the lack of flow in the artery and/or renal vein, high peak systolic velocity (with values >300 cm/s), parvus tardus pulse waveforms, and the marked reduction or absence of parenchymal renal flow. In the aforementioned study 47 patients reported at least 1 of these vascular changes and the Doppler US scan in 16 patients has indicated surgery for compartment syndrome (n = 7), renal vein thrombosis (n = 3), renal artery thrombosis (n = 1), renal artery and vein thrombosis (n = 2), and vascular steal (n = 1). In 2 patients there were no vascular abnormalities at the time of reintervention. In all 16 patients marked reduction of renal parenchymal flow, changes in peak systolic velocity, and renal vascular flow alterations were observed.

The study pointed out that in the immediate postoperative period, a number of vascular changes identified with Doppler examination, in particular including the massive reduction of renal parenchymal flow, put the indication for resurgery quickly to prevent the loss of the graft. However, as already pointed out, this examination is not able to make a differential diagnosis between various causes responsible for the vascular changes before the patient reaches the operating table. Therefore, if the onset of RACS is suspected or possible, the unique opportunity to safeguard the function of the transplanted kidney is to perform a surgical decompression as early as possible by adopting tension-free closure techniques.

Treatment of RACS

According to the data of literature examined, there are critical points in terms of both early diagnosis and regarding the timing of the surgical treatment of RACS. The recovery of the transplanted kidney is possible by surgical decompression, which restores the physiological vascular flow.

In the various studies examined, the definitive diagnosis of RACS was made on the operating table, despite the use of Doppler US scan. The flow alterations detected by US are not specific, being common in other post-transplantation complications. In fact, according to Horrow et al [20], Doppler US monitoring of transplanted kidney located approximately 8% of patients with abnormal flow; of these, only 34% were subjected to an urgent reintervention, and half of these were really suffering from RACS for which decompression warranted restoration of function. Given this experience with patients affected by RACS, there are experiences of other authors who acted before the onset of RACS, performing surgical decompression techniques during the transplantation, as in studies of Richards [23] and Pentlow [24]. In a series of 600 transplanted patients, Wood [13] performed decompression techniques on 134 (22%); among these, 123 (20.5%) underwent closure of the abdominal wall with polypropylene prosthesis during transplantation, as the discrepancy between the space of positioning and the size of the kidney was at high risk of onset of RACS in the immediate postoperative period; in 11 patients (1.8%) decompression was performed early post-transplantation for the onset of a real RACS. In both cases the recovery, survival of kidney and patients were almost identical. Therefore, the only data in common in all the studies examined is the surgical technique, which consists of the creation of a space of greater dimensions in which to allocate the kidney to reduce the endoabdominal pressure through the use of prosthesis. For this purpose, based on the experience of the various groups, the following different types of prostheses were used [25]: (1) porcine mesh "Permacol"; (2) PTFE dual mesh prosthesis; and (3) polypropylene-assisted mesh hood fascial closure (MHFC).

Richards et al [23] have used prosthetic porcine collagen (Permacol) to facilitate the closure of the abdominal wall after transplantation of a kidney from adult cadaver donor to a 2-year-old recipient who weighed 12 kg. The prosthesis in this case was implanted between the rectus muscles and fixed with continuous suture in PDS, without complications. Subsequently, the authors treated two other pediatric patients the same way.

Similarly, Pentlow et al [24] published a study on the use of porcine prostheses in the closure of the abdominal wall in 5 pediatric recipients (5–12 years) of adult donors, followed for 3 years, during which it proved to be a useful aid in all cases of kidney transplantation in which there was a size discrepancy between donor and recipient.

Our group used prosthetics dual-mesh PTFE, for the onset of RACS in a 42-year-old female kidney transplanted patient, in which compartment syndrome was due to the narrow space in which the graft was transplanted [1]. The closure of the abdominal wall with tension-free technique has allowed us to recover the functionality of the graft.

Other authors as Nguan et al [26] and Wood [13] described the use of MHFC for closure of the abdominal wall with tension-free technique both during kidney transplantation in patients considered at risk of RACS is in the post-transplantation period after verification of the increase in intra-abdominal pressure.

In further studies examined, if the onset of RACS is expected and it is not possible to decompress the abdominal wall using the techniques above described due to a high risk of infection, surgical techniques have been implemented that involve the allocation of the transplanted kidney in the sub-cutaneous or intraperitoneal site. Ball et al [11] adopted the subcutaneous positioning of transplanted kidney in 3 patients diagnosed with RACS, transplanted by transretroperitoneal way in the right iliac fossa. In 2 patients there was a significant difference in size compared to donors. The follow up of these cases showed an excellent renal function after transplantation. Koss et al [27] describes the intraperitoneal positioning of previously transplanted kidney in the iliac fossa that caused a compartment syndrome due to excessive intra-abdominal tension. Ball et al [11] reported intraperitoneal placement of the transplanted kidney as treatment of RACS in 8 patients. In both studies, there were no surgical complications and there was a restoration of function of the graft after the reintervention.

CONCLUSION

Early detection of RACS is the key to preventing the loss of the graft, to facilitate surgical decompression that will allow functional recovery of the transplanted kidney.

To date the only means to identify the syndrome are clinical suspicion and monitoring by Doppler US, which, however, may provide morphofunctional information common to several post-transplantation complications, instead of allowing an early certain diagnosis of RACS. Benefits were shown in a study by Fontana et al on pediatric recipients using intravesical pressure as an indirect estimation of intra-abdominal pressure. In the same study, color Doppler was used both in the immediate postoperative period to evaluate vascular changes consistent with the development of a compartment syndrome after surgery and to determine surgical timing. The reoperation in the immediate post-transplantation period appears to be burdened by a significant risk for both for the patient and the graft. Indeed, it is necessary to identify all the conditions and factors already present before transplantation that could raise suspicion of a development of RACS and act preventively before the onset of this syndrome. Ideally, the allocation of organs would follow a discrepancy in weight between donor and recipient less than 17%; however, due to the shortage of organs, this criterion is not always possible. Therefore in our opinion, it is necessary to identify groups at risk of developing RACS before being transplanted and

implementing methods of abdominal decompression during the transplantation itself.

Based on studies of literature we reviewed and our experience we have identified the following risk conditions:

(1) anatomical conditions of the recipient:
 − Small basin.
 − Polycystic kidneys in situ.
 − All those conditions in which difficulty of allocation of kidney in the iliac fossa is expected.
(2) Conditions related to the graft:
 − Discrepancy between donor weight and weight of the recipient.
 − Organs from obese donor.
 − Organs from adult donors for pediatric recipients.
(3) Iatrogenic conditions post-transplantation:
 − Closure of the abdominal wall with excessive tension.
 − Massive post-transplantation lymphoceles.

Lacking guidelines universally accepted in the various transplant centers, the closure of the muscle-aponeurotic wall with tension-free techniques should be adopted for all of these conditions described above to prevent RACS. Furthermore, there are no guidelines regarding the use of prostheses; in general a biological prosthesis is used (Permacol) when the use of synthetic prostheses is not favorable or is contraindicated, as in the case of a potential source of infection. However, synthetic prostheses are currently used [28] and in the studies reviewed there were differences in the incidence of infection and/or complications. Indeed, we must dispel the subjective opinion entry of the increased incidence of infectious complications by using prosthetic mesh in such immunosuppressed patients.

Finally, in those rare cases in which the closure of the wall by affixing the prosthetic mesh is not favorable, or is contraindicated, there are alternative techniques such as positioning the graft in the subcutaneous or intraperitoneal space.

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