



# Transition of care from pediatric to adult nephrology post-renal transplant: a review

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**Abstract:** Pediatric renal transplant recipients (RTRs) face heightened risks when they transition from a childhood nephrologist to an adult-centered one. The transition of care usually occurs when an individual is between ages 18 and 21 years, although some change providers earlier or later depending on varying circumstances. Turbulence during this shift can significantly impact daily life and, in severe cases, lead to graft loss. Several modern studies have explored the transition from pediatric to adult-centered nephrology care post-renal transplant. In this review, we first provide an overview of the differences between pediatric and adult renal transplant, highlighting unique challenges faced by pediatric patients such as donor-recipient size disparity, growth impairment, and need for additional immunizations. We then emphasize the criticality of a well-planned transition process, identifying factors that can hinder a smooth transition—such as medical and medication nonadherence, lack of health literacy, patient psychosocial challenges, and systemic shortcomings in coordination between care teams. Furthermore, this review outlines existing protocols and risk assessment tools, in addition to highlighting recent advancements aimed at facilitating smoother transitions such as the RISE protocol, readiness assessment, and the use of multidisciplinary teams. Proper implementation of coordinated, evidence-based transition protocols can improve patient outcomes, promote medication and appointment adherence, and reduce graft rejection rates. Efforts from multidisciplinary teams utilizing technology, risk stratification tools, and open communication between providers and patients are key to optimizing the transition process for pediatric RTRs as they transfer to adult-centered care.

**Keywords:** Pediatric renal transplant; transition of care; graft failure; medical nonadherence; risk stratification tools

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## Introduction

Patients with end-stage renal disease (ESRD) often receive renal transplants in the progression of their care. ESRD indicates extremely low kidney function [estimated glomerular filtration rate (eGFR) <15 mL/min] and can result from uncontrolled diabetes, hypertension,

glomerulonephritis, polycystic kidney disease, vesicoureteral reflux, and more (1). In 2022, approximately 26,309 individuals in the United States received renal transplants. This number increased to 27,332 in 2023, demonstrating a consistent upward trend in renal transplant procedures over the years. Furthermore, there were 715 pediatric

transplants conducted in 2020 in the United States, which rose to 820 in 2021 (2,3). Research indicates that pediatric patients undergoing renal transplant experience lower 1-year mortality rates compared to those undergoing dialysis, highlighting the benefits of transplantation in this population (4).

Of the total kidney transplants in 2021, 5,714 were from living donors while 18,827 were from deceased donors. Notably, patients transplanted with living donors had improved 5-year graft survival compared to deceased donor counterparts. Among individuals aged 18–34 years, graft survival was 88.6% *vs.* 80.7%, for living donors and deceased donors, respectively (2). Nonetheless, it has been established that renal transplants are imperative to increase lifespan in those with ESRD compared to patients staying on dialysis. However, after renal transplantation, these patients can encounter several adverse outcomes that can limit their recovery time and kidney function.

Renal transplant recipients (RTRs) can have severe or even fatal postoperative complications, and studies have shown that the odds ratio (OR) for mortality in kidney transplant recipients compared to non-transplant patients is 2.2 for cardiac surgery and general surgery, with 95% confidence intervals (CIs) ranging from 1.9 to 2.5 and 1.3 to 4.0, respectively (5). Acute kidney injury (AKI) emerges as the most prevalent nonfatal complication, affecting both donors (before organ retrieval) and recipients (following transplantation), either shortly after the procedure or over time. In a retrospective study performed by Hod *et al.* over 12 years, the incidence of AKI was 37% for pediatric renal transplant patients (6). Around 30% of transplanted kidneys from deceased donors develop AKI post-transplantation (7). Additionally, pediatric patients can face complications after transplantation due to being immunocompromised. These complications include severe viral infections from respiratory syncytial virus (RSV), influenza, cytomegalovirus (CMV), and Epstein-Barr virus (EBV) (8). Hence, the transition of care from pediatric to adult settings is paramount and warrants meticulous planning by nephrologists.

Several factors contribute to the success of renal transplants and the reduction of graft rejection, among which are a patient's age at the time of transplant and medical adherence. Younger age at transplant and medical nonadherence pose a greater risk for complications. A study conducted by Kindem *et al.* concluded that medical nonadherence was strongly implicated with graft loss during the transition period (ages 14–26 years), affecting 58% of total cases in this group compared to only 12% of total

cases for older ages (ages 25–56 years) (9). As previously stated, these outcomes indicate that proper transition of care between pediatric to adult nephrology care is required for effective transplant outcomes. Awareness of the guidelines for a seamless transition to adult care can therefore significantly improve outcomes and decrease the risk of graft rejection.

Furthermore, a comprehensive transition program helps mitigate the stressors faced when patients shift from a pediatric to an adult care team. Such a program facilitates patients' understanding of their treatment plans, educates them on the roles and responsibilities involved, and provides crucial support in managing any treatment-related complications, including AKI. By fostering continuity of care and empowering patients with the necessary knowledge and resources, transition programs play a crucial role in optimizing long-term outcomes for pediatric RTRs as they navigate the challenges of adulthood.

In this review, we first discuss key elements of pediatric renal transplantation and explain significant problems these recipients encounter. Next, we highlight the importance of effective transition and emphasize factors that can lead to a more turbulent transition from pediatric to adult care. Finally, this review strives to introduce various models used to ease the transition process and discuss modern advancements to clinical practice.

## Methods

Information for this review was collected through a systematic search of the PubMed database. The search strategy involved the utilization of relevant keywords related to pediatric renal transplant and associated themes. The keywords used included “pediatric renal transplant”, “pediatric *vs.* adult renal transplant”, “transition of care”, “benefits and risks of pediatric renal transplant”, “graft failure”, “medical adherence”, “risk stratification tools”, “appointment nonadherence”, and “multidisciplinary teams in providing care”. These keywords were chosen to encompass various aspects of pediatric renal transplantation, including clinical outcomes, patient management, and predictive factors. The inclusion criteria focused on several types of articles, including systematic reviews, clinical trials, review articles, meta-analyses, books, and documents.

The search was performed by entering each keyword individually and in combination with others using Boolean operators (AND, OR) to maximize the retrieval of relevant studies. The initial search results were screened by title

and abstract, followed by full-text review for eligibility based on the inclusion criteria. Both first authors were responsible for conducting the data extraction to ensure accuracy and consistency in the data included for analysis. The collected data were subjected to qualitative synthesis to identify key themes and patterns within the literature. Descriptive statistics were used to summarize the findings, and thematic analysis was applied to categorize the various aspects of pediatric renal transplantation discussed in the reviewed articles. This approach facilitated a comprehensive understanding of the current state of knowledge and identified gaps for future research.

## Discussion

### *Pediatric care*

In 2021, pediatric renal transplants represented a modest fraction of the total number of renal transplants in the United States, comprising only 820 out of a total of 24,670 procedures being performed (2). Pediatric renal transplants present unique challenges compared to those in adults, necessitating careful consideration of factors such as donor-recipient size disparity, potential for growth retardation, and adherence to medication regimens (10). Additionally, literature shows that the estimated half-life for a pediatric kidney transplant is 12–15 years, and children who undergo renal transplants at younger ages therefore need subsequent renal transplants throughout their lifetime. In the United States, while children experience low rates of acute rejection (11%), chronic allograft loss is a major threat for these young individuals. Furthermore, nonadherence also contributes to 23% of late acute rejection episodes for adolescent kidney transplant patients (8). Given the heightened risks associated with pediatric renal transplantation, proper timing of the transplant procedure and planned transition of care are imperative to optimize outcomes for these individuals.

Pediatric transplant patients differ from adult counterparts due to the causes of ESRD, optimal donor match, types of complications, growth impairments, and the requirement for additional immunizations before renal transplants. Additionally, cardiovascular health concerns persist in this population, albeit to a lesser extent, including obesity, hyperglycemia, hypercholesterolemia, and hypertension. Furthermore, children with ESRD who undergo renal transplant at earlier ages have underdeveloped immune systems and are less likely to have immunity to major viruses

such as CMV, EBV, or BK/JC polyomaviruses. Therefore, polyoma neuropathy is a major complication for children with renal transplants. These patients are often EBV or CMV-naïve and are therefore considered a high-risk group for viremia, especially if they receive renal transplants from positive donors. It has been documented that approximately 20% of pediatric RTRs are considered high risk for CMV infections and 40% at risk for EBV infections. Regular monitoring of EBV viremia can help mitigate these risks (11). Proper management, including starting treatment early on, initiating prophylaxis, and careful monitoring of complications, is essential for ensuring favorable outcomes in pediatric transplant patients (12).

Despite the potential challenges, the benefits of renal transplants for children appear to outweigh the risks. Research indicates that pediatric transplant recipients experience enhanced growth, improved neurocognitive development, better academic performance, and an overall higher quality of life compared to children undergoing dialysis. Multiple studies have noted improvements in neurocognitive functioning post-renal transplant. A prospective cohort study conducted by van Sandwijk *et al.* noted that working memory and attention improve within the first year of transplant compared to baseline. This improvement was further elaborated by Gupta *et al.*, who stated that episodic and verbal declarative memory show stabilization post-transplant, while there is an improvement in semantic memory, verbal fluency, and language (13,14). Moreover, pediatric kidney transplant recipients demonstrate impressive long-term survival rates, with 10-year patient survival ranging from 90% to 95%. These findings underscore the critical role of renal transplantation in improving the health outcomes and overall well-being of pediatric patients with ESRD (8).

### *Importance of planned transition*

Transition of care for pediatric RTRs is defined as a long-term, planned process describing the movement of patients from a pediatric nephrology clinic to an adult-centered one. Transfer is defined as the actual change of a new adult provider or healthcare facility, occurring towards the end of a transition process. The transition of care is deemed successful when adolescents with renal transplants achieve self-competence and independence while maintaining a high quality of life (15). Studies have found that anywhere from 24% to 35% of patients experience a graft loss within 3 years when transition of care is initiated (16). When this

happens, some RTRs require the need to return to dialysis treatment, leading to a decline in quality of life and an increase in healthcare costs.

The transition period is an important time for RTRs. Pediatric patients go from having parents or guardians manage their health to handling all aspects of their care on their own. Pediatric RTRs transitioning to adult care must learn to manage insurance, follow-up appointments, and other responsibilities that were previously maintained by caretakers (17). On top of this, patients must cope with the usual responsibilities of becoming adults as they face the new burden of managing finances, a family, and other duties. Any hurdle in this process can have severe clinical, psychological, and social implications, potentially leading to mental health issues and an overall decline in health. Proper transition involves intersectional care coordinated between multiple members of the healthcare team, including patients, parents, pediatric nephrologists, adult nephrologists, nurses, social workers, and dieticians (18).

A study performed by Samuel *et al.* observed that out of 413 pediatric RTRs, 149 were transferred to adult care during a certain period. Strikingly, 78 of the 149 patients (52%) developed severe graft failure after the transition to adult care (19). Additionally, the study noted that the risk of graft loss during the adaptation period, defined as 6 months before transplant and 2.5 years after transfer to adult care, was notably higher compared to before and after this period. Specifically, graft failure occurred in 38 patients before the adaptation period (equating to 2.2 per 100-person years), 23 patients during the adaptation period (6.6 per 100-person years), and 17 patients after this period (5.5 per 100-person years) (19). A poorly planned transition can result in significant patient consequences and increase the broader healthcare burden on providers.

Open communication is required between the patient, family, and pediatric and adult nephrologists to facilitate the proper transition. Inadequate communication can lead patients to feel confused, ultimately leading to medical nonadherence and worsened clinical outcomes. In a survey conducted by Raina *et al.*, less than 60% of nephrologists said that practice, protocols, and treatment plans are efficiently communicated between adult and pediatric teams. Furthermore, only 30% reported extra involvement of the primary care physician during the transition process (17). It can be hypothesized that this lack of communication between care teams might precipitate a lack of communication with patients as well. An unorganized care plan, if under- or mis-communicated to the patient,

may result in medication nonadherence and exacerbate symptoms. The pediatric transplant team, adult transplant team, and primary care team must be in regular and detailed communication so that a unified care plan can be presented to the patient, leading to an open conversation that takes their problems and preferences into account. Patient involvement is also important throughout the transition process, and studies have shown it encourages health literacy and promotes adherence. A series of meetings between patient and provider before and after transition should be scheduled to help facilitate comprehension of treatment regimes.

Several studies have been performed to examine the current state and satisfaction scores of patients undergoing the transition of the care process. For example, in a retrospective study performed by Raina *et al.*, it was found that about half of RTRs begin the transition process between ages 16 and 18 years, while the others begin at ages below 16 years. This data was obtained by analyzing a survey result from 60 nephrologists in 49 centers around the United States (17). A patient's age at the time of transfer is another main factor contributing to the success of the transition of care and medical compliance post-transfer. While the specific age of transfer varies between patients, it is recommended to transfer to adult care around the age of 21. A retrospective cohort study conducted by Foster *et al.*, recognized that individuals transferred to adult care before 21 years of age had a 60% higher risk of graft failure compared to individuals older than 21 years. Older individuals may have a higher level of maturity, and therefore are more adherent in following a strict treatment plan (20). Presently, there exists not only variability between the stakeholders involved in RTR transition processes but also a notable lack of communication between pediatric and adult nephrology care teams. This issue is compounded by the underutilization of readiness surveys and other transition of care protocols, despite their documented benefits (17). It is imperative to meticulously plan the transition protocol for pediatric renal transplant patients to improve clinical and psychosocial outcomes.

## Patient-related issues

### *Nonadherence to medication*

Avoiding prescribed medications or not following a physician's order is termed medication nonadherence. Adherence is defined as taking medications in the right

**Table 1** OR for various clinical outcomes

Clinical outcomes	OR (95% CI)
Graft rejection	2.28 (1.15–4.45)
Mortality	2.66 (1.37–5.15)
Graft loss	6.44 (2.71–16.6)

OR, odds ratio; CI, confidence interval.

amount and at the right time. Persistence is defined as the constant administration of these medications. In kidney transplant patients, nonadherence is a multifactorial phenomenon involving a dynamic interplay between adherence and persistence (21). Nonadherence to immunosuppressant medications in post-transplant patients can lead to graft rejection and other adverse effects. Measuring medication nonadherence can be challenging, but some currently accepted models include measuring the quantity of drug in a patient's blood (coefficient of variation of tacrolimus) or documenting the time delay in refilling prescriptions.

One retrospective cohort study examining the outcomes of non-adherence in renal transplant found after multivariate analysis that nonadherence was associated with worse outcomes overall. Specifically, these patients had an OR of 2.28 (95% CI: 1.15–4.45) for graft rejection, 2.66 (95% CI: 1.37–5.15) for mortality, and 6.44 (95% CI: 2.71–16.6) for graft loss. There was also a six-fold increase in graft loss for non-adherent patients (22).

Multiple factors can lead to medication nonadherence, including insufficient income to obtain proper medications, lack of social support, chronic stress levels, forgetfulness, avoidance of side effects, difficulties in accessing pharmacies, and other life events and stressors (23). However, addressing this issue is complex due to the presence of numerous racial disparities, causing unintended problems for both patients and providers. A study conducted by Oates *et al.*, found that African Americans had a statistically significant correlation with non-adherence, revealing that even with close to full medication coverage, minorities were 40% less likely to adhere to prescribed treatments compared to the rest of the population. The same study reported that participants with more than three social risk factors (education of high school or less, annual income, high chronic stress, and low social support) had higher odds of medication nonadherence (OR =4.16; 95% CI: 2.35–7.37;  $P<0.001$ ) compared to patients without social risk factors (24). These studies indicate that numerous socioeconomic risk factors play a significant role

in medication adherence, and therefore in the rate of graft rejection in RTRs (Table 1).

### *Nonadherence to follow-up appointments*

Nonadherence to follow-up appointments is another factor contributing to graft loss. It is estimated that 5.8 cases per 100 patients every year are nonadherent to appointments in the United States (25). In a study performed in 2016, those with appointment nonadherence were 1.5 times more likely to experience graft rejection: 22% (appointment nonadherence) *vs.* 14.7% (appointment adherence). Medication non-adherence can exacerbate and compound these negative effects. A study led by Taber *et al.*, found that RTRs who did not adhere to medications, in addition to non-adherence to follow-up appointments, had a 65% higher risk of graft loss (hazard ratio =1.65; 95% CI: 1.38–1.97;  $P<0.0001$ ). Based on the results of the same study, it was concluded that there was a strong, positive, dose-dependent relationship between appointment nonadherence and risk of graft loss ( $R^2=0.856$ ). In the study, every 1% increase in appointment nonadherence was correlated with approximately a 5% increase in the adjusted hazard ratio for graft loss ( $P<0.001$ ) (25).

Studies have also been performed to address the factors that lead to follow-up appointment nonadherence. Two significant factors include racial discrimination and patient locus of control. The patient locus of control is defined as the extent to which a person feels control over the events that influence their life. It was found that patients who felt racial discrimination present in their initial doctor's visit had lower adherence to follow-up appointments (OR =0.31; 95% CI: 0.12–0.76). Likewise, patients who had a higher internal locus of control had greater adherence to follow-up appointments (OR =1.46; 95% CI: 1.06–2.03) (26). Working to eliminate racial bias in the doctor's office and providing patients with the techniques to allow them to take ownership over their healthcare needs, can improve appointment adherence and help to decrease graft rejection rates.

A patient-centered model that seeks to understand patient concerns can also help alleviate issues with appointment follow-up. By taking the time to understand a patient's barriers to accessing care, a physician can work to solve these issues and improve outcomes. Moreover, flexibility between physician and provider is critical to this process. For example, switching from in-person to telemedicine appointments may be one way to ensure better visit compliance and follow-

up. Furthermore, a collaborative, team-based approach to educating patients and working with patient's preferences and schedules can lead to better appointment adherence outcomes.

### ***Lack of health literacy and psychological disorders***

It has been observed that pediatric transplant patients often exhibit deficits in social and emotional maturity, coupled with a lack of understanding regarding the underlying causes of their disease. Anxiety disorders, particularly post-traumatic stress disorder (PTSD), are frequently reported among these patients following renal transplant. Additionally, generalized anxiety disorder manifests at higher rates in young transplant recipients, primarily stemming from concerns about their future. The resumption of school and other responsibilities often exacerbates feelings of social isolation, leading to further negative consequences and outcomes (27). Pediatric transplant patients commonly experience a range of psychological challenges, including denial of their condition, dissatisfaction with their physical appearance, and loss of hope regarding romantic relationships. These psychological issues underscore the importance of comprehensive support and mental health interventions early on in a pediatric transplant recipients medical journey to enhance their overall well-being and adjustment to life post-transplant (28).

Patients transitioning from pediatric to adult nephrology clinics also feel that they lack the required health knowledge needed to manage different aspects of their health independently. This effect was increased for pediatric patients who underwent transplants at a younger age, as all healthcare instructions were directed toward their parents. When these patients begin to undergo the transition process to independent adult care, they can feel overwhelmed and underprepared, making them more likely to be non-adherent to medications and appointments, and engage in risky behaviors (29).

It has been noted that RTRs, especially those of lower socioeconomic status or minority background, may face disruptions in their education. Having higher education levels leads RTRs to be more adherent to immunosuppressant medications and decreases associated risks of depression or other adverse psychological effects. A prospective, cross-sectional study consisting of 297 participants performed by Prihodova *et al.* noticed that higher education levels in female participants were

associated with full adherence to immunosuppressive treatment. A similar conclusion was drawn by Hedayati *et al.*, who reported that lower levels of education resulted in a decreased rate of compliance with medications. A descriptive, analytic study was performed including 170 renal transplant patients enrolled in a hospital located in Iran, and they also noted similar findings (30,31).

Emotional support from parents, healthcare providers, or other patients with similar health status can provide improved results for RTRs. These patients are prone to be negatively affected by social stressors like re-entering school, living independently, moving to a new home, and finding a job, and support provided by a strong social network can reduce these concerns. Furthermore, RTRs tend to live with their parents for longer than their peers, leading to feelings of dissatisfaction, loss of autonomy, and a negative attitude about their health. A solid support system is vital to navigating psychosocial stressors and easing the overall transition from pediatric to adult care (32).

Each of these patient-related issues can contribute, both individually and in combination, to a difficult transition from pediatric to adult-centered care. Having correct systems in place aids in mitigating some of the stressors associated with the transition process, improves post-transplant outcomes, and decreases the risk of graft loss.

### **Current protocols and risk stratification tools**

#### ***RISE protocol and multidisciplinary teams***

The RISE protocol was developed to address efficient transition of care between pediatric to adult nephrology clinics. RISE stands for Recognition, Insight, Self-Reliance, and Establishment of Healthy Habits. The recognition and insight components are in place to educate the patient about their diagnosis, including medication adherence and further treatment. Likewise, self-reliance and the establishment of healthy habits help promote patient autonomy and a proper lifestyle (17).

Ensuring a seamless transition for RTRs requires collaborative efforts from various stakeholders. The core contributors include the patient, their family, and the pediatric transplant team. This group is complemented by the transition team, comprising of the social worker, transition coordinator, community resource providers, and other pertinent professionals. Additionally, the involvement of the adult transplant team and primary care provider is vital as they can provide indispensable support and

**Table 2** Describes the individuals involved in multidisciplinary healthcare teams

Team member	Specific role in the team
Pediatric & adult nephrologist	Proper communication between pediatric and adult physicians is key to a successful transition. Provides individualized care, promotes medication management, and assesses medication adherence
Transition coordinator	Provides patient education and improves health literacy; acts as a point of contact between patients and various healthcare personnel
Pharmacist	Reviews medications regularly, provides information on proper medication use for patients, and works with physicians to simplify medication regimens
Social worker	Provides resources for patients- financial assistance, counseling services, psychosocial assessments
Psychologist/psychiatrist	Offers mental health support for patients and provide cognitive behavioral therapy
Nutritionist/dietician	Monitors patients' dietary protocols and provides suggestions to fulfill daily requirements; Helps promote a healthy lifestyle post-transplant
Telehealth services	Offers virtual follow-up appointments and monitor patients' health status remotely
Care coordinator	Collaborates with all healthcare members for the patient and assesses progress towards successful transition; addresses any challenges faced early on

information to aid the transition. Furthermore, smaller healthcare facilities may experience a challenging time transitioning pediatric transplant patients if they lack proper communication with the larger hospital system. Establishing a successful transition of care for transplant patients requires the combined effort of multiple teams to maximize support. Initiating efficient communication channels with delineated roles and responsibilities among these parties is crucial to ensure that the patient undergoes a smooth and effective transition of care (17).

Various specialized tools have been developed and utilized by providers to ease the transition process. Among these are the medical passport and milestone checklist. The passport serves as a centralized repository for the patient's medical history and helps the patient stay in communication with their healthcare provider regarding the treatment plan and future goals. Likewise, the milestone checklist has been developed to help providers check the health of their transplant patients and adjust treatment plans accordingly. In addition to these assessment tools, kidney transplant questionnaires and readiness assessments have been established, helping the patient stay aware of short-term and long-term progress goals post-kidney transplantation (17) (*Table 2*).

### *Age of transition*

The timing of transition holds significant importance, influencing various factors such as medication adherence

and graft survival rates, and serves as an effective metric aiding healthcare providers in assessing the readiness of pediatric patients to transition to adult care. Notably, advancing donor and recipient age correlates with enhanced graft survival rates. A study revealed that during the transition period from ages 17 to 24 years, approximately 42.4% of patients were projected to experience graft loss as they age. Extrapolating from this data, it was concluded that individuals transitioning at a younger age face heightened risks of graft loss (33,34). Consequently, multiple studies have advocated for commencing the transition process around the age of 21 years to improve care outcomes (17,35).

Three stages have been established to ease the transition process from pediatric to adult care. The initial pre-transition stage spans from age 14 to 18 years. During this period, the pediatric team collaborates with both the patient and their family to assess the existing circumstances and offer educational resources aimed at enhancing understanding of renal transplants. This is a pivotal juncture for the family to evaluate the financial resources and social support available for the patient's journey ahead. A transition plan will be created at this stage as a way of communication between the patient, the pediatric care team, the adult care team, and the primary care provider. The active transition process lasts from age 18 to 21 years and marks the time when the patient has a joint meeting with the pediatric and adult care team to have open communication about treatment plans and future goals. Lastly, the post-transition stage occurs when a patient is

21–26 years of age and is marked by a complete transfer to adult care (17).

### **Current transition protocol tools**

Pediatric providers employ several tools to evaluate the readiness of RTRs for transfer and address any gaps in preparation for this transition. The readiness assessment tool involves a qualitative interview conducted by the pediatric nephrologist with the patient. Through this assessment, the patient's understanding of their renal transplant, the importance of medication adherence, follow-up appointments, and overall self-efficacy are evaluated. Identified gaps in knowledge can prompt educational interventions to enhance health literacy and address these deficiencies. Furthermore, a readiness checklist serves as a self-administered tool for patients to assess their knowledge and readiness for transition. The transition action plan complements these assessments by facilitating counseling services for patients who may require mental health support. It mirrors and augments the readiness checklist in identifying any areas that may require further guidance or explanation. Collectively, these tools can contribute to a successful transition process for RTRs (36).

There are additional tools, guidelines, and recommendations set by various hospital systems to guide a smooth transition from pediatric to adult care. The first is called the transition/transfer process form, which outlines the steps to be performed by each member of the healthcare team. It covers an extensive timeline, delineating clear instructions from 2 years pre-transplant until 90 days after transition to an adult specialist. The next form is for communication purposes, confirming how patients prefer to be contacted by an adult nephrologist. This is followed by the patient/provider Questionnaire, which lists questions for patients designed to help them evaluate and choose an adult provider. A transition action plan is utilized by patients after their first adult nephrology visit and provides a bridge between the pediatric and adult nephrologist. Finally, a parent action form is employed by the patient's caretaker to assist in guiding the patient toward assuming responsibility and independence (17,36,37).

Providing individualized support for patients through education programs, simplified or alternative medication options, regular follow-up appointments, and psychosocial support while closely monitoring and addressing deviations from adherence is crucial to support the transition process and decrease the risk of graft failure (Table 3).

### **Using technology to bridge the gap**

Electronic monitoring (EM) has been established as one way to measure medication nonadherence. The implementation of text medication reminders has led to improved medication compliance and better monitoring of other post-transplantation factors that require patient compliance, such as sodium intake. A recent review, performed by Hezer *et al.*, about the current uses of telemedicine in kidney transplant recipients noted that sending text reminders also increases the rate of attending follow-up appointments and other health visits (risk ratio =1.14; 95% CI: 1.03–1.26) (38). Other forms of eHealth for RTRs include the use of Smartphone Medication trays, Video-consultation with providers, and remote healthcare monitoring devices (38). Presently, there are also smartphone apps and phone alarms that provide patients with medication timing, dosage, and appointment reminders (39,40). Furthermore, the use of various technology tools including computerized dosing led to less variability in trough tacrolimus levels and fewer medication errors (41). Additionally, there is an increased need for follow-up appointments post-renal transplant, and the use of telehealth has helped decrease the burden for patients and providers by reducing travel time and other unnecessary costs (42).

For RTRs, hypertension is a common problem that requires frequent monitoring. Poor control of blood pressure is an added risk for graft rejection. A study performed by Aberger *et al.*, found improved control of blood pressure levels when patients used a home electronic blood pressure monitoring device and uploaded data to an online patient profile monitored regularly by a clinical pharmacist that provided feedback directly to patients (43). However, there are several barriers to the use of technology, such as lack of patient digital literacy, age, cost, insurer reimbursements, and state licensure restrictions (42).

### **Limitations of the study and future directions**

The scarcity of written guidelines reflects the inconsistent care that may be provided across health organizations. For example, the RISE protocol implements clinical recommendations that are subject to variation from one healthcare facility to another. Furthermore, surveys have indicated inconsistent use of validated tools despite their widespread availability and report a communication gap between adult and pediatric healthcare teams. Even for the various study tools provided in the literature, many



**Table 3** The various strategies used by healthcare professionals to promote patient adherence

Strategy type	Description of strategy
Patient education	Ensures patients are informed about the importance of adherence (medications, follow-up appointments) and promotes health literacy
Simplified medication plan	Provides appropriate and easy to access medications; reduces the number of pills by utilizing combination therapy
Individualized care plan	Incorporates patient feedback to form a customized treatment plan that addresses medical status and patient preferences
Addressing financial concerns	Connects patients with financial support to ensure patients can afford medications and proper health care; prescribes cost-effective medications by utilizing generic or alternative medication options
Psychosocial support	Monitors patients' psychosocial health by providing regular health screenings; helps connect patients with peer groups to provide social support
Technology implementation	Utilizes telehealth when applicable to monitor patient's status and incorporates electronic methods (pill bottles) to monitor patient adherence
Early intervention	Monitoring patients regularly to address deviations in adherent behavior or other health concerns early on to prevent further complications

have a limited sample size, which may provide inadequate insight into the current state of transitional care provided to post-renal transplant patients and a lack of representation of varying geographic territories. Additionally, financial allocation and staff qualifications are often lacking, preventing timely and optimal patient care.

Successful transition from pediatric to adult care for renal transplant patients requires a plethora of resources and can face many obstacles. Moving forward, new cohort studies with large sample sizes are required to identify patterns and trends in treatment efficacy and efficiency. Pediatric teams, adult teams, and all supporting, staff involved in the transition care required additional medical education regarding clinical practice and management. Furthermore, medical financing of transition medicine needs to be made a priority for health policymakers and insurance companies to minimize barriers to successful treatment and transition for pediatric renal transplant patients. Gathering survey data on patients' preferences and perspectives, alongside insights from both adult and pediatric nephrologists, is crucial for achieving a comprehensive and effective transition of care stemming from the patient perspective. This holistic, patient-centered approach ensures that the transition process is tailored to meet the unique needs and preferences of each patient, fostering a more successful continuum of care.

## Conclusions

Establishing guidelines promoting a smooth transition from

pediatric to adult-centered nephrology care for RTRs is vital to short and long-term patient outcomes. There are several barriers to successful transition, including medication and/or appointment non-adherence, personal factors related to the patients, and system-wide deficits. Careful, long-term planning between patients and their pediatric nephrology team is required to determine the proper age of transfer. In addition, utilizing risk stratification tools such as the readiness assessment or the RISE protocol can also contribute to an improved transition process. The literature and data regarding transition of care for RTRs is constantly evolving, and new protocols and guidelines can further contribute to better provider readiness and enhanced patient care.

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