

# Approach to Optimizing Growth, Rehabilitation, and Neurodevelopmental Outcomes in Children After Solid-organ Transplantation

Saeed Mohammad, MD\*, Estella M. Alonso, MD

## KEYWORDS

- Growth • Cognitive function • Quality of life
- Liver transplantation • Kidney transplantation
- Heart transplantation • Intestinal transplantation

One of the most critical differences between the posttransplant care of children and adults is the essential requirement in children to maintain a state of health that supports normal physical and psychological growth and development. Most children with organ failure have some degree of growth failure and developmental delay, which is not quickly reversed after successful transplantation. Thus, the challenge for clinicians caring for these children is to use strategies that minimize these deficits before transplantation and provide maximal opportunity for recovery of normal developmental processes during posttransplant rehabilitation. The effect of chronic organ failure, frequently complicated by malnutrition, on growth potential and cognitive development is poorly understood. Likewise, although immunosuppressive medications including corticosteroids and calcineurin inhibitors have known side effects that negatively affect growth and neurologic function the dose-response relationships of these medications and time course of their toxicities are still an area of active investigation. This review presents a summary of what is known regarding risk factors for suboptimal growth and development following solid-organ transplant and describes possible strategies to improve these outcomes.

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Department of Pediatrics, Northwestern University Feinberg School of Medicine, Siragusa Transplant Center, Children's Memorial Hospital, 2300 Children's Plaza, Box 65, Chicago, IL 60614, USA

\* Corresponding author.

*E-mail address:* [smohammad@childrensmemorial.org](mailto:smohammad@childrensmemorial.org)

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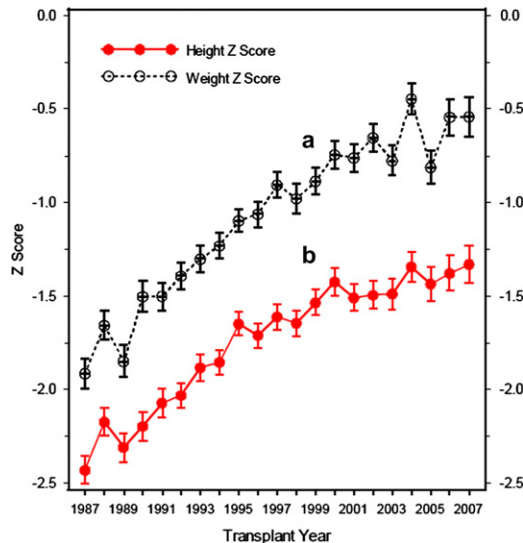
## GROWTH

Measurements of physical growth include height, weight, and lean muscle mass. Few studies of pediatric solid-organ transplantation recipients have included measurements of muscle mass, making it difficult to comment on this element of growth. Weight gain is a parameter that has been carefully studied and it seems to be an aspect of growth that recovers fully in patients with adequate graft function, despite a history of previous malnutrition. Therefore, this review focuses on optimizing linear growth following transplantation in recipients of kidney, liver, cardiac, lung, and intestinal transplantation.

### *Kidney Recipients*

There are multiple factors that impair linear growth in children with chronic kidney disease, including inadequate nutritional intake, chronic acidosis, renal osteodystrophy, and growth hormone resistance. Improvements in the care of children with end-stage renal disease (ESRD) targeting these clinical problems have reduced the severity of growth retardation in children approaching renal transplantation. Data collected through the North American Pediatric Renal Trials Collaborative (NAPRTCS) show the improvement in linear growth in children with ESRD in the past 20 years.<sup>1</sup> The mean height standard deviation score (SDS or z score) at the time of initial transplant has improved from a  $-2.4$  in 1987 to  $-1.3$  in the 2007 cohort (**Fig. 1**). Catch-up growth has been demonstrated in the youngest recipients, with a mean increase in height SDS of 0.55 for those aged 2 to 5 years and 0.66 for those aged 0 to 1 year by 2 years after transplant.<sup>1</sup> However, children older than 6 years at the time of transplant exhibit almost no increase in SDS for height in the early posttransplant period (**Fig. 2**).

Several factors have been identified that adversely affect catch-up linear growth following kidney transplant. A recent review by Fine<sup>2</sup> details early age at transplant,



**Fig. 1.** Standardized z scores at time of kidney transplant by year of transplant. (a) Improvement in weight z scores at time of kidney transplant from  $-1.91$  to  $-0.54$ . (b) Improvement in height z scores from  $-2.43$  to  $-1.33$ . (Courtesy of NAPRTCS [North American Pediatric Renal Trials and Collaborative Studies]. <https://web.emmes.com/study/ped/>; with permission.)

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