

CHEMOTHERAPY

ALKYLATING AGENTS (CONT)

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
18	Classical Alkylating Agents Cyclophosphamide Ifosfamide	Urinary tract toxicity Hemorrhagic cystitis Bladder fibrosis Dysfunctional voiding Vesicoureteral reflux Hydronephrosis	HISTORY Hematuria Urinary urgency/frequency Urinary incontinence/retention Dysuria Nocturia Abnormal urinary stream Yearly	HEALTH LINKS Bladder Health COUNSELING Promptly report dysuria or gross hematuria. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Urinalysis, urine culture, spot urine calcium/creatinine ratio for patients with positive history. Ultrasound of kidneys and bladder for patients with microscopic hematuria (defined as >5 RBC/HPF on at least 2 occasions). Nephrology or urology referral for patients with culture-negative microscopic hematuria AND abnormal ultrasound and/or abnormal calcium/creatinine ratio. Urology referral for patients with culture-negative macroscopic hematuria, incontinence, or dysfunctional voiding. SYSTEM = Urinary SCORE = 1

Additional Information

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Cancer/Treatment factors: Higher cumulative doses (decreased incidence with Mesna), especially cyclophosphamide dose ≥ 3 gm/m², combination with pelvic radiation, especially pelvic radiation dose ≥ 30 Gy
- Health behaviors: Alcohol use, smoking

References

- Dieffenbach BV, Liu Q, Murphy AJ, et al: Late-onset kidney failure in survivors of childhood cancer: a report from the Childhood Cancer Survivor Study. *Eur J Cancer* 155:216-226, 2021
- Green DM, Wang M, Krasin M, et al: Kidney function after treatment for childhood cancer: a report from the St. Jude Lifetime Cohort Study. *J Am Soc Nephrol* 32(4):983-993, 2021
- Hale GA, Marina NM, Jones-Wallace D, et al: Late effects of treatment for germ cell tumors during childhood and adolescence. *J Pediatr Hematol Oncol* 21:115-22, 1999
- Heyn R, Raney RB, Jr., Hays DM, et al: Late effects of therapy in patients with paratesticular rhabdomyosarcoma. Intergroup Rhabdomyosarcoma Study Committee. *J Clin Oncol* 10:614-23, 1992
- Jerkins GR, Noe HN, Hill D: Treatment of complications of cyclophosphamide cystitis. *J Urol* 139:923-5, 1988
- Kooijmans EC, Bökenkamp A, Tjahjadi NS, et al: Early and late adverse renal effects after potentially nephrotoxic treatment for childhood cancer. *Cochrane Database Syst Rev* 11;3(3), 2019
- Lima MV, Ferreira FV, Macedo FY, et al: Histological changes in bladders of patients submitted to ifosfamide chemotherapy even with mesna prophylaxis. *Cancer Chemother Pharmacol* 59:643-50, 2007
- Stillwell TJ, Benson RC, Jr.: Cyclophosphamide-induced hemorrhagic cystitis. A review of 100 patients. *Cancer* 61:451-7, 1988
- Stillwell TJ, Benson RC, Jr., Burgert EO, Jr.: Cyclophosphamide-induced hemorrhagic cystitis in Ewing's sarcoma. *J Clin Oncol* 6:76-82, 1988

CHEMOTHERAPY

ALKYLATING AGENTS (CONT)

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
20	Classical Alkylating Agents Ifosfamide	Renal toxicity Glomerular injury Renal insufficiency Hypertension Tubular injury (renal tubular acidosis, Fanconi syndrome, hypophosphatemic rickets)	PHYSICAL Blood pressure Yearly SCREENING BUN Creatinine Na, K, Cl, CO₂, Ca, Mg, PO₄ Baseline at entry into long-term follow-up, repeat as clinically indicated	HEALTH LINKS Kidney Health Cardiovascular Risk Factors COUNSELING In patients with salt-wasting tubular dysfunction, educate that low magnesium levels potentiate coronary atherosclerosis. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Electrolyte supplements for patients with persistent electrolyte wasting. Nephrology consultation for patients with hypertension or progressive renal insufficiency. SYSTEM = Urinary SCORE = 1

Additional Information

Ifosfamide-related renal toxicity typically occurs during the acute treatment phase and improves or progresses over time.

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Patient factors: Younger age at treatment, especially age <4 years
- Cancer/Treatment factors: Tumor infiltration of kidney(s), nephrectomy, higher cumulative dose, especially ifosfamide dose ≥ 60 grams/m², combination with other nephrotoxic agents (e.g., cisplatin, carboplatin, aminoglycosides, amphotericin, immunosuppressants, methotrexate, radiation impacting the kidney), renal radiation dose ≥ 15 Gy
- Pre-morbid/Co-morbid medical conditions: Pre-existing renal impairment, congenital absence of kidney

References

- Arndt C, Morgenstern B, Hawkins D, et al: Renal function following combination chemotherapy with ifosfamide and cisplatin in patients with osteogenic sarcoma. *Med Pediatr Oncol* 32:93-6, 1999
- Burk CD, Restaino I, Kaplan BS, et al: Ifosfamide-induced renal tubular dysfunction and rickets in children with Wilms tumor. *J Pediatr* 117:331-5, 1990
- Ceremuzynski L, Gebalska J, Wolk R, et al: Hypomagnesemia in heart failure with ventricular arrhythmias. Beneficial effects of magnesium supplementation. *J Intern Med* 247:78-86, 2000
- Dekkers IA, Blijdorp K, Cransberg K, et al: Long-term nephrotoxicity in adult survivors of childhood cancer. *Clin J Am Soc Nephrol* 8:922-9, 2013
- Fels LM, Bokemeyer C, van Rhee J, et al: Evaluation of late nephrotoxicity in long-term survivors of Hodgkin's disease. *Oncology* 53:73-8, 1996
- Ho PT, Zimmerman K, Wexler LH, et al: A prospective evaluation of ifosfamide-related nephrotoxicity in children and young adults. *Cancer* 76:2557-64, 1995
- Langer T, Stohr W, Bielack S, et al: Late effects surveillance system for sarcoma patients. *Pediatr Blood Cancer* 42:373-9, 2004
- Loebstein R, Atanackovic G, Bishai R, et al: Risk factors for long-term outcome of ifosfamide-induced nephrotoxicity in children. *J Clin Pharmacol* 39:454-61, 1999
- Raney B, Ensign LG, Foreman J, et al: Renal toxicity of ifosfamide in pilot regimens of the intergroup rhabdomyosarcoma study for patients with gross residual tumor. *Am J Pediatr Hematol Oncol* 16:286-95, 1994
- Skinner R, Cotterill SJ, Stevens MC: Risk factors for nephrotoxicity after ifosfamide treatment in children: a UKCCSG Late Effects Group study. United Kingdom Children's Cancer Study Group. *Br J Cancer* 82:1636-45, 2000
- Skinner R, Sharkey IM, Pearson AD, et al: Ifosfamide, mesna, and nephrotoxicity in children. *J Clin Oncol* 11:173-90, 1993
- Stohr W, Paulides M, Bielack S, et al: Ifosfamide-induced nephrotoxicity in 593 sarcoma patients: a report from the Late Effects Surveillance System. *Pediatr Blood Cancer* 48:447-52, 2007

CHEMOTHERAPY

HEAVY METALS (CONT)

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
23	Heavy Metals Carboplatin Cisplatin	Renal toxicity Glomerular injury Renal insufficiency Hypertension Tubular injury (renal tubular acidosis, Fanconi syndrome, hypophosphatemic rickets)	PHYSICAL Blood pressure Yearly SCREENING BUN Creatinine Na, K, Cl, CO₂, Ca, Mg, PO₄ Baseline at entry into long-term follow-up, repeat as clinically indicated	HEALTH LINKS Kidney Health Cardiovascular Risk Factors COUNSELING In patients with salt-wasting tubular dysfunction, educate that low magnesium levels potentiate coronary atherosclerosis. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Electrolyte supplements for patients with persistent electrolyte wasting. Nephrology consultation for patients with hypertension or progressive renal insufficiency. SYSTEM = Urinary SCORE = 2A

Additional Information

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Cancer/Treatment factors: Nephrectomy, combination with other nephrotoxic agents (e.g., aminoglycosides, amphotericin, immunosuppressants, methotrexate, radiation impacting the kidney), cisplatin dose ≥ 200 mg/m², renal radiation dose ≥ 15 Gy
- Pre-morbid/Co-morbid medical conditions: Diabetes mellitus, hypertension, congenital absence of kidney

References

- Arndt C, Morgenstern B, Hawkins D, et al: Renal function following combination chemotherapy with ifosfamide and cisplatin in patients with osteogenic sarcoma. *Med Pediatr Oncol* 32:93-6, 1999
- Bianchetti MG, Kanaka C, Ridolfi-Luthy A, et al: Persisting renotubular sequelae after cisplatin in children and adolescents. *Am J Nephrol* 11:127-30, 1991
- Ceremuzynski L, Gebalska J, Wolk R, et al: Hypomagnesemia in heart failure with ventricular arrhythmias. Beneficial effects of magnesium supplementation. *J Intern Med* 247:78-86, 2000
- Hutchison FN, Perez EA, Gandara DR, et al: Renal salt wasting in patients treated with cisplatin. *Ann Intern Med* 108:21-5, 1988
- Jimenez-Triana CA, Castelan-Martinez OD, Rivas-Ruiz R, et al: Cisplatin nephrotoxicity and longitudinal growth in children with solid tumors: a retrospective cohort study. *Medicine (Baltimore)* 94:e1413, 2015
- Liao F, Folsom AR, Brancati FL: Is low magnesium concentration a risk factor for coronary heart disease? The Atherosclerosis Risk in Communities (ARIC) Study. *Am Heart J* 136:480-90, 1998
- Stohr W, Paulides M, Bielack S, et al: Nephrotoxicity of cisplatin and carboplatin in sarcoma patients: a report from the late effects surveillance system. *Pediatr Blood Cancer* 48:140-7, 2007
- von der Weid NX, Erni BM, Mamie C, et al: Cisplatin therapy in childhood: renal follow up 3 years or more after treatment. *Swiss Pediatric Oncology Group. Nephrol Dial Transplant* 14:1441-4, 1999

RADIATION

POTENTIAL IMPACT TO URINARY TRACT

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
86	Abdomen TBI	Renal toxicity Glomerular injury Renal insufficiency Hypertension	PHYSICAL Blood pressure Yearly SCREENING BUN Creatinine Na, K, Cl, CO₂, Ca, Mg, PO₄ Baseline at entry into long-term follow-up, repeat as clinically indicated	HEALTH LINKS Kidney Health Cardiovascular Risk Factors POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Nephrology consultation for patients with hypertension or progressive renal insufficiency. <div style="border: 1px solid black; padding: 5px; text-align: center;"> SYSTEM = Urinary SCORE = 1 </div>

Additional Information

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Cancer/Treatment factors: Bilateral Wilms tumor, nephrectomy, radiomimetic chemotherapy (e.g., doxorubicin, dactinomycin), combination with other nephrotoxic agents (e.g., cisplatin, carboplatin, ifosfamide, aminoglycosides, amphotericin, immunosuppressants), radiation dose ≥ 10 Gy, especially radiation dose ≥ 15 Gy, TBI ≥ 6 Gy in single fraction, TBI ≥ 12 Gy fractionated, TBI combined with radiation to the kidney
- Pre-morbid/Co-morbid medical conditions: Diabetes mellitus, hypertension, congenital absence of kidney

References

- Dekkers IA, Blijdorp K, Cransberg K, et al: Long-term nephrotoxicity in adult survivors of childhood cancer. *Clin J Am Soc Nephrol* 8:922-9, 2013
- Delgado J, Cooper N, Thomson K, et al: The importance of age, fludarabine, and total body irradiation in the incidence and severity of chronic renal failure after allogeneic hematopoietic cell transplantation. *Biol Blood Marrow Transplant* 12:75-83, 2006
- Dieffenbach BV, Liu Q, Murphy AJ, et al: Late-onset kidney failure in survivors of childhood cancer: a report from the Childhood Cancer Survivor Study. *Eur J Cancer* 155:216-226, 2021
- Fels LM, Bokemeyer C, van Rhee J, et al: Evaluation of late nephrotoxicity in long-term survivors of Hodgkin's disease. *Oncology* 53:73-8, 1996
- Frisk P, Bratteby LE, Carlson K, et al: Renal function after autologous bone marrow transplantation in children: a long-term prospective study. *Bone Marrow Transplant* 29:129-36, 2002
- Green DM, Wang M, Krasin M, et al: Kidney function after treatment for childhood cancer: a report from the St. Jude Lifetime Cohort Study. *J Am Soc Nephrol* 32(4):983-993, 2021
- Gronroos MH, Bolme P, Winiarski J, et al: Long-term renal function following bone marrow transplantation. *Bone Marrow Transplant* 39:717-23, 2007
- Knijnenburg SL, Jaspers MW, van der Pal HJ, et al: Renal dysfunction and elevated blood pressure in long-term childhood cancer survivors. *Clin J Am Soc Nephrol* 7:1416-27, 2012
- Lawton CA, Cohen EP, Murray KJ, et al: Long-term results of selective renal shielding in patients undergoing total body irradiation in preparation for bone marrow transplantation. *Bone Marrow Transplant* 20:1069-74, 1997
- Miralbell R, Bieri S, Mermillod B, et al: Renal toxicity after allogeneic bone marrow transplantation: the combined effects of total-body irradiation and graft-versus-host disease. *J Clin Oncol* 14:579-85, 1996
- Ritchey ML, Green DM, Thomas PR, et al: Renal failure in Wilms' tumor patients: a report from the National Wilms' Tumor Study Group. *Med Pediatr Oncol* 26:75-80, 1996
- Tarbell NJ, Guinan EC, Niemeyer C, et al: Late onset of renal dysfunction in survivors of bone marrow transplantation. *Int J Radiat Oncol Biol Phys* 15:99-104, 1988

RADIATION

POTENTIAL IMPACT TO URINARY TRACT (CONT)

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
87	Pelvis Spine (sacral, whole)	Urinary tract toxicity Hemorrhagic cystitis Bladder fibrosis Dysfunctional voiding Vesicoureteral reflux Hydronephrosis	HISTORY Hematuria Urinary urgency/frequency Urinary incontinence/retention Dysuria Nocturia Abnormal urinary stream Yearly	HEALTH LINKS Bladder Health COUNSELING Promptly report dysuria or gross hematuria. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Urinalysis, urine culture, spot urine calcium/creatinine ratio for patients with positive history. Ultrasound of kidneys and bladder for patients with microscopic hematuria (defined as >5 RBC/HPF on at least 2 occasions). Nephrology or urology referral for patients with culture-negative microscopic hematuria AND abnormal ultrasound and/or abnormal calcium/creatinine ratio. Urology referral for patients with culture-negative macroscopic hematuria, incontinence, or dysfunctional voiding. SYSTEM = Urinary SCORE Hemorrhagic cystitis = 2A All Else = 1

Additional Information

The bladder is included in the left and right flank/hemiabdomen treatment fields only if the fields extended below iliac crest.
Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Cancer/Treatment factors: Higher radiation dose, especially ≥ 30 Gy to entire bladder, ≥ 45 Gy to portion of bladder, combination with cyclophosphamide, ifosfamide or vincristine

References

Hale GA, Marina NM, Jones-Wallace D, et al: Late effects of treatment for germ cell tumors during childhood and adolescence. *J Pediatr Hematol Oncol* 21:115-22, 1999

Levy A, Martelli H, Fayeck C, et al: Late toxicity of brachytherapy after female genital tract tumors treated during childhood: Prospective evaluation with a long-term follow-up. *Radiother Oncol* 117:206-12, 2015

Marks LB, Carroll PR, Dugan TC, et al: The response of the urinary bladder, urethra, and ureter to radiation and chemotherapy. *Int J Radiat Oncol Biol Phys* 31:1257-80, 1995

Piver MS, Rose PG: Long-term follow-up and complications of infants with vulvovaginal embryonal rhabdomyosarcoma treated with surgery, radiation therapy, and chemotherapy. *Obstet Gynecol* 71:435-7, 1988

Raney B, Jr., Heyn R, Hays DM, et al: Sequelae of treatment in 109 patients followed for 5 to 15 years after diagnosis of sarcoma of the bladder and prostate. A report from the Intergroup Rhabdomyosarcoma Study Committee. *Cancer* 71:2387-94, 1993

Soler R, Macedo A, Jr., Bruschini H, et al: Does the less aggressive multimodal approach of treating bladder-prostate rhabdomyosarcoma preserve bladder function? *J Urol* 174:2343-6, 2005

Stillwell TJ, Benson RC, Jr.: Cyclophosphamide-induced hemorrhagic cystitis. A review of 100 patients. *Cancer* 61:451-7, 1988

Stillwell TJ, Benson RC, Jr., Burgert EO, Jr.: Cyclophosphamide-induced hemorrhagic cystitis in Ewing's sarcoma. *J Clin Oncol* 6:76-82, 1988

Yeung CK, Ward HC, Ransley PG, et al: Bladder and kidney function after cure of pelvic rhabdomyosarcoma in childhood. *Br J Cancer* 70:1000-3, 1994

HEMATOPOIETIC CELL TRANSPLANT (CONT)

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
104	Hematopoietic Cell Transplant (HCT)	Renal toxicity Glomerular injury Renal insufficiency Hypertension Tubular injury (renal tubular acidosis, Fanconi syndrome, hypophosphatemic rickets)	PHYSICAL Blood pressure Yearly SCREENING BUN Creatinine Na, K, Cl, CO₂, Ca, Mg, PO₄ Baseline at entry into long-term follow-up, repeat as clinically indicated	HEALTH LINKS Kidney Health Cardiovascular Risk Factors COUNSELING In patients with salt-wasting tubular dysfunction, educate that low magnesium levels potentiate coronary atherosclerosis. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Electrolyte supplements for patients with persistent electrolyte wasting. Nephrology consultation for patients with hypertension or progressive renal insufficiency. SYSTEM = Urinary SCORE = 1

Additional Information

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Patient factors: Older age
- Cancer/Treatment factors: Chronic cyclosporine use, TBI
- Pre-morbid/Co-morbid medical conditions: Acute kidney injury within 6 months of HCT, history of chronic GVHD

References

- Abbound I, Porcher R, Robin M, et al: Chronic kidney dysfunction in patients alive without relapse 2 years after allogeneic hematopoietic stem cell transplantation. *Biol Blood Marrow Transplant* 15:1251-7, 2009
- Al-Hazzouri A, Cao Q, Burns LJ, et al: Similar risks for chronic kidney disease in long-term survivors of myeloablative and reduced-intensity allogeneic hematopoietic cell transplantation. *Biol Blood Marrow Transplant* 14:658-63, 2008
- Ando M, Ohashi K, Akiyama H, et al: Chronic kidney disease in long-term survivors of myeloablative allogeneic haematopoietic cell transplantation: prevalence and risk factors. *Nephrol Dial Transplant* 25:278-82, 2010
- Ceremuzynski L, Gebalska J, Wolk R, et al: Hypomagnesemia in heart failure with ventricular arrhythmias. Beneficial effects of magnesium supplementation. *J Intern Med* 247:78-86, 2000
- Choi M, Sun CL, Kurian S, et al: Incidence and predictors of delayed chronic kidney disease in long-term survivors of hematopoietic cell transplantation. *Cancer* 113:1580-7, 2008
- Ellis MJ, Parikh CR, Inrig JK, et al: Chronic kidney disease after hematopoietic cell transplantation: a systematic review. *Am J Transplant* 8:2378-90, 2008
- Esiashvili N, Chiang KY, Hasselle MD, et al: Renal toxicity in children undergoing total body irradiation for bone marrow transplant. *Radiother Oncol* 90:242-6, 2009
- Gerstein J, Meyer A, Sykora KW, et al: Long-term renal toxicity in children following fractionated total-body irradiation (TBI) before allogeneic stem cell transplantation (SCT). *Strahlenther Onkol* 185:751-5, 2009
- Hoffmeister PA, Hingorani SR, Storer BE, et al: Hypertension in long-term survivors of pediatric hematopoietic cell transplantation. *Biol Blood Marrow Transplant* 16:515-24, 2010
- Majhail NS, Challa TR, Mulrooney DA, et al: Hypertension and diabetes mellitus in adult and pediatric survivors of allogeneic hematopoietic cell transplantation. *Biol Blood Marrow Transplant* 15:1100-7, 2009
- Nieder ML, McDonald GB, Kida A, et al: National Cancer Institute-National Heart, Lung and Blood Institute/Pediatric Blood and Marrow Transplant Consortium First International Consensus Conference on late effects after pediatric hematopoietic cell transplantation: long-term organ damage and dysfunction. *Biol Blood Marrow Transplant* 17:1573-84, 2011

SURGERY

CYSTECTOMY

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
116	Cystectomy	Cystectomy-related complications Asymptomatic bacteriuria Chronic urinary tract infection Renal dysfunction Vesicoureteral reflux Hydronephrosis Reservoir calculi Spontaneous neobladder perforation Vitamin B12/folate/carotene deficiency (patients with ileal enterocystoplasty only)	SCREENING Vitamin B12 level Yearly, starting 5 years after cystectomy (patients with ileal enterocystoplasty only) Evaluation by urologist Yearly	HEALTH LINKS Cystectomy Kidney Health <div style="border: 1px solid black; padding: 10px; text-align: center;"> SYSTEM = Urinary SCORE Reservoir calculi = 2A Vitamin B12/folate/carotene deficiency = 2B All Else = 1 </div>

Additional Information

All potential late effects for pelvic surgery apply to cystectomy (see also sections 141–145).
 Reservoir calculi are stones in the neobladder (a reservoir for urine usually constructed of ileum/colon).

References

Castagnetti M, Angelini L, Alaggio R, et al: Oncologic outcome and urinary function after radical cystectomy for rhabdomyosarcoma in children: role of the orthotopic ileal neobladder based on 15-year experience at a single center. *J Urol* 191:1850-5, 2014

DeFoor W, Tackett L, Minevich E, et al: Risk factors for spontaneous bladder perforation after augmentation cystoplasty. *Urology* 62:737-41, 2003

Hautmann RE, de Petroni R, Gottfried HW, et al: The ileal neobladder: complications and functional results in 363 patients after 11 years of followup. *J Urol* 161:422-7; discussion 427-8, 1999

Hensle TW, Bingham J, Lam J, et al: Preventing reservoir calculi after augmentation cystoplasty and continent urinary diversion: the influence of an irrigation protocol. *BJU Int* 93:585-7, 2004

Inouye BM, Shah BB, Massanyi EZ, et al: Urologic complications of major genitourinary reconstruction in the exstrophy-epispadias complex. *J Pediatr Urol* 10:680-7, 2014

Jahson S, Pedersen J: Cystectomy and urinary diversion during twenty years--complications and metabolic implications. *Eur Urol* 24:343-9, 1993

Kaloo NB, Jeffs RD, Gearhart JP: Long-term nutritional consequences of bowel segment use for lower urinary tract reconstruction in pediatric patients. *Urology* 50:967-71, 1997

Metcalfe PD, Casale AJ, Kaefer MA, et al: Spontaneous bladder perforations: a report of 500 augmentations in children and analysis of risk. *J Urol* 175:1466-70; discussion 1470-1, 2006

Raney B, Jr., Heyn R, Hays DM, et al: Sequelae of treatment in 109 patients followed for 5 to 15 years after diagnosis of sarcoma of the bladder and prostate. A report from the Intergroup Rhabdomyosarcoma Study Committee. *Cancer* 71:2387-94, 1993

Rosenbaum DH, Cain MP, Kaefer M, et al: Ileal enterocystoplasty and B12 deficiency in pediatric patients. *J Urol* 179:1544-7; discussion 1547-8, 2008

Sim HG, Lau WK, Cheng CW: A twelve-year review of radical cystectomies in Singapore General Hospital. *Ann Acad Med Singapore* 31:645-50, 2002

Stewart D, Inouye BM, Goldstein SD, et al: Pediatric surgical complications of major genitourinary reconstruction in the exstrophy-epispadias complex. *J Pediatr Surg* 50:167-70, 2015

SURGERY

NEPHRECTOMY

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
121 (male)	Nephrectomy	Hydrocele Renal toxicity Proteinuria Hyperfiltration Renal insufficiency Hypertension	PHYSICAL Height Weight BMI Blood pressure Yearly Testicular exam to evaluate for hydrocele Yearly SCREENING BUN Na, K, Cl, CO₂, Ca, Mg, PO₄ Baseline at entry into long-term follow-up, repeat as clinically indicated Urine dipstick for protein Creatinine with calculated eGFR* Yearly *eGFR Calculator available at: https://www.niddk.nih.gov/health-information/communication-programs/nkdep/laboratory-evaluation/glomerular-filtration-rate-calculators	HEALTH LINKS Single Kidney Health Kidney Health Cardiovascular Risk Factors COUNSELING Counsel mononephric survivors regarding sports and activity safety, stressing the importance of physical fitness, and proper use of seatbelts (i.e., wearing lap belts around hips, not waist). Consideration should be given to survivor health status, current kidney health (position, size, function), and acceptability of unlikely risk of sports-related renal injury to the survivor and/or family. Use NSAIDs with caution. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Nephrology consultation for patients with hypertension, proteinuria, or progressive renal insufficiency. <div style="border: 1px solid black; background-color: #00728f; color: white; padding: 5px; text-align: center;"> SYSTEM = Urinary SCORE = 1 </div>

Additional Information

Surgery-induced renal atrophy (vanishing kidney) is a rare complication reported in survivors who have undergone retroperitoneal tumor resections. Once this diagnosis is established, annual screening should include evaluations recommended for children treated with nephrectomy.

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Cancer/Treatment factors: Bilateral Wilms tumor, combination with other nephrotoxic therapy (e.g., cisplatin, carboplatin, ifosfamide, aminoglycosides, amphotericin, immunosuppressants, methotrexate, radiation impacting the kidneys)
- Pre-morbid/Co-morbid medical conditions: Denys-Drash syndrome, WAGR syndrome, hypospadias, cryptorchidism

References

- Bailey S, Roberts A, Brock C, et al: Nephrotoxicity in survivors of Wilms' tumours in the North of England. *Br J Cancer* 87:1092-8, 2002
- Breslow NE, Collins AJ, Ritchey ML, et al: End stage renal disease in patients with Wilms tumor: results from the National Wilms Tumor Study Group and the United States Renal Data System. *J Urol* 174:1972-5, 2005
- Cozzi DA, Ceccanti S, Frediani S, et al: Renal function adaptation up to the fifth decade after treatment of children with unilateral renal tumor: a cross-sectional and longitudinal study. *Pediatr Blood Cancer* 60:1534-8, 2013

Section 121 References (cont)

- Dieffenbach BV, Liu Q, Murphy AJ, et al: Late-onset kidney failure in survivors of childhood cancer: a report from the Childhood Cancer Survivor Study. *Eur J Cancer* 155:216-226, 2021
- Finklestein JZ, Norkool P, Green DM, et al: Diastolic hypertension in Wilms' tumor survivors: a late effect of treatment? A report from the National Wilms' Tumor Study Group. *Am J Clin Oncol* 16:201-5, 1993
- Ginsberg JP, Hobbie WL, Ogle SK, et al: Prevalence of and risk factors for hydrocele in survivors of Wilms tumor. *Pediatr Blood Cancer* 42:361-3, 2004
- Green DM, Wang M, Krasin M, et al: Kidney function after treatment for childhood cancer: a report from the St. Jude Lifetime Cohort Study. *J Am Soc Nephrol* 32(4):983-993, 2021
- Grinsell MM, Showalter S, Gordon KA, et al: Single kidney and sports participation: perception versus reality. *Pediatrics* 118:1019-27, 2006
- Hubertus J, Gunther B, Becker K, et al: Development of hypertension is less frequent after bilateral nephron sparing surgery for bilateral Wilms tumor in a long-term survey. *J Urol* 193:262-6, 2015
- Johnson B, Christensen C, Dirusso S, et al: A need for reevaluation of sports participation recommendations for children with a solitary kidney. *J Urol* 174:686-9; discussion 689, 2005
- Mitus A, Tefft M, Fellers FX: Long-term follow-up of renal functions of 108 children who underwent nephrectomy for malignant disease. *Pediatrics* 44:912-21, 1969
- Paulino AC, Wen BC, Brown CK, et al: Late effects in children treated with radiation therapy for Wilms' tumor. *Int J Radiat Oncol Biol Phys* 46:1239-46, 2000
- Ritchey ML, Green DM, Thomas PR, et al: Renal failure in Wilms' tumor patients: a report from the National Wilms' Tumor Study Group. *Med Pediatr Oncol* 26:75-80, 1996
- Sharp DS, Ross JH, Kay R: Attitudes of pediatric urologists regarding sports participation by children with a solitary kidney. *J Urol* 168:1811-4; discussion 1815, 2002
- Srinivas M, Agarwala S, Padhy AK, et al: Somatic growth and renal function after unilateral nephrectomy for Wilms' tumor. *Pediatr Surg Int* 14:185-8, 1998

SURGERY

NEPHRECTOMY (CONT)

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
122 (female)	Nephrectomy	Renal toxicity Proteinuria Hyperfiltration Renal insufficiency Hypertension	PHYSICAL Height Weight BMI Blood pressure Yearly SCREENING BUN Na, K, Cl, CO₂, Ca, Mg, PO₄ Baseline at entry into long-term follow-up, repeat as clinically indicated Urine dipstick for protein Creatinine with calculated eGFR* Yearly *eGFR Calculator available at: https://www.niddk.nih.gov/health-information/communication-programs/nkdep/laboratory-evaluation/glomerular-filtration-rate-calculators	HEALTH LINKS Single Kidney Health Kidney Health Cardiovascular Risk Factors COUNSELING Counsel mononephric survivors regarding sports and activity safety, stressing the importance of physical fitness, and proper use of seatbelts (i.e., wearing lap belts around hips, not waist). Consideration should be given to survivor health status, current kidney health (position, size, function), and acceptability of unlikely risk of sports-related renal injury to the survivor and/or family. Use NSAIDs with caution. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Nephrology consultation for patients with hypertension, proteinuria, or progressive renal insufficiency. <div style="background-color: #00728f; color: white; padding: 10px; text-align: center;"> SYSTEM = Urinary SCORE = 1 </div>

Additional Information

Surgery-induced renal atrophy (vanishing kidney) is a rare complication reported in survivors who have undergone retroperitoneal tumor resections. Once this diagnosis is established, annual screening should include evaluations recommended for children treated with nephrectomy.

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Cancer/Treatment factors: Bilateral Wilms tumor, combination with other nephrotoxic therapy (e.g., cisplatin, carboplatin, ifosfamide, aminoglycosides, amphotericin, immunosuppressants, methotrexate, radiation impacting the kidneys)
- Pre-morbid/Co-morbid medical conditions: Denys-Drash syndrome, WAGR syndrome

References

- Bailey S, Roberts A, Brock C, et al: Nephrotoxicity in survivors of Wilms' tumours in the North of England. *Br J Cancer* 87:1092-8, 2002
- Breslow NE, Collins AJ, Ritchey ML, et al: End stage renal disease in patients with Wilms tumor: results from the National Wilms Tumor Study Group and the United States Renal Data System. *J Urol* 174:1972-5, 2005
- Cozzi DA, Ceccanti S, Frediani S, et al: Renal function adaptation up to the fifth decade after treatment of children with unilateral renal tumor: a cross-sectional and longitudinal study. *Pediatr Blood Cancer* 60:1534-8, 2013
- Dieffenbach BV, Liu Q, Murphy AJ, et al: Late-onset kidney failure in survivors of childhood cancer: a report from the Childhood Cancer Survivor Study. *Eur J Cancer* 155:216-226, 2021
- Finklestein JZ, Norkool P, Green DM, et al: Diastolic hypertension in Wilms' tumor survivors: a late effect of treatment? A report from the National Wilms' Tumor Study Group. *Am J Clin Oncol* 16:201-5, 1993

Section 122 References (cont)

- Green DM, Wang M, Krasin M, et al: Kidney function after treatment for childhood cancer: a report from the St. Jude Lifetime Cohort Study. *J Am Soc Nephrol* 32(4):983-993, 2021
- Grinsell MM, Showalter S, Gordon KA, et al: Single kidney and sports participation: perception versus reality. *Pediatrics* 118:1019-27, 2006
- Hubertus J, Gunther B, Becker K, et al: Development of hypertension is less frequent after bilateral nephron sparing surgery for bilateral Wilms tumor in a long-term survey. *J Urol* 193:262-6, 2015
- Johnson B, Christensen C, Dirusso S, et al: A need for reevaluation of sports participation recommendations for children with a solitary kidney. *J Urol* 174:686-9; discussion 689, 2005
- Mitus A, Tefft M, Fellers FX: Long-term follow-up of renal functions of 108 children who underwent nephrectomy for malignant disease. *Pediatrics* 44:912-21, 1969
- Paulino AC, Wen BC, Brown CK, et al: Late effects in children treated with radiation therapy for Wilms' tumor. *Int J Radiat Oncol Biol Phys* 46:1239-46, 2000
- Ritchey ML, Green DM, Thomas PR, et al: Renal failure in Wilms' tumor patients: a report from the National Wilms' Tumor Study Group. *Med Pediatr Oncol* 26:75-80, 1996
- Sharp DS, Ross JH, Kay R: Attitudes of pediatric urologists regarding sports participation by children with a solitary kidney. *J Urol* 168:1811-4; discussion 1815, 2002
- Srinivas M, Agarwala S, Padhy AK, et al: Somatic growth and renal function after unilateral nephrectomy for Wilms' tumor. *Pediatr Surg Int* 14:185-8, 1998

SURGERY

PELVIC SURGERY

Sec #	Therapeutic Exposure	Potential Late Effects	Periodic Evaluation	Health Counseling/ Further Considerations
141	Pelvic surgery Cystectomy	Urinary incontinence Urinary tract obstruction	HISTORY Urinary urgency/frequency Urinary incontinence/retention Dysuria Nocturia Abnormal urinary stream Yearly	COUNSELING Importance of adequate fluid intake, regular voiding, and seeking medical attention for symptoms of voiding dysfunction or urinary tract infection. Importance of compliance with recommended bladder catheterization regimen. POTENTIAL CONSIDERATIONS FOR FURTHER TESTING AND INTERVENTION Urologic consultation for patients with dysfunctional voiding or recurrent urinary tract infections. SYSTEM = Urinary SCORE = 1

Additional Information

For patients with cystectomy, see also section 116.

Consider patient and cancer/treatment factors, pre-morbid/co-morbid health conditions, and health behaviors, as appropriate, that may increase risk.

- Pre-morbid/Co-morbid medical conditions: Tumor adjacent to or compressing spinal cord or cauda equina, retroperitoneal node dissection, extensive pelvic dissection (e.g., bilateral ureteral re-implantation, retroperitoneal tumor resection), radiation to the bladder, pelvis, and/or lumbar-sacral spine

References

- Derikx JPM, De Backer A, van de Schoot L, et al: Long-term functional sequelae of sacrococcygeal teratoma: a national study in the Netherlands. *J Pediatr Surg* 42:1122-1126, 2007
- Hale GA, Marina NM, Jones-Wallace D, et al: Late effects of treatment for germ cell tumors during childhood and adolescence. *J Pediatr Hematol Oncol* 21:115-22, 1999
- Heyn R, Raney RB, Jr., Hays DM, et al: Late effects of therapy in patients with paratesticular rhabdomyosarcoma. Intergroup Rhabdomyosarcoma Study Committee. *J Clin Oncol* 10:614-23, 1992
- Koyle MA, Hatch DA, Furness PD, et al: Long-term urological complications in survivors younger than 15 months of advanced stage abdominal neuroblastoma. *J Urol* 166:1455-1458, 2001
- Kremer ME, Derikx JP, van Baren R, et al: Patient-reported defecation and micturition problems among adults treated for sacrococcygeal teratoma during childhood--the need for new surveillance strategies. *Pediatr Blood Cancer* 63:690-4, 2016
- Ozkan KU, Bauer SB, Khoshbin S, et al: Neurogenic bladder dysfunction after sacrococcygeal teratoma resection. *J Urol* 175:292-296, 2006
- Raney B, Anderson J, Jenney M, et al: Late effects in 164 patients with rhabdomyosarcoma of the bladder/prostate region: A report from the international workshop. *J Urol* 176:2190-2194, 2006