



A Parent's Guide to Understanding

Retinoblastoma



Memorial Sloan Kettering
Cancer Center

Acknowledgements



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What is Retinoblastoma?

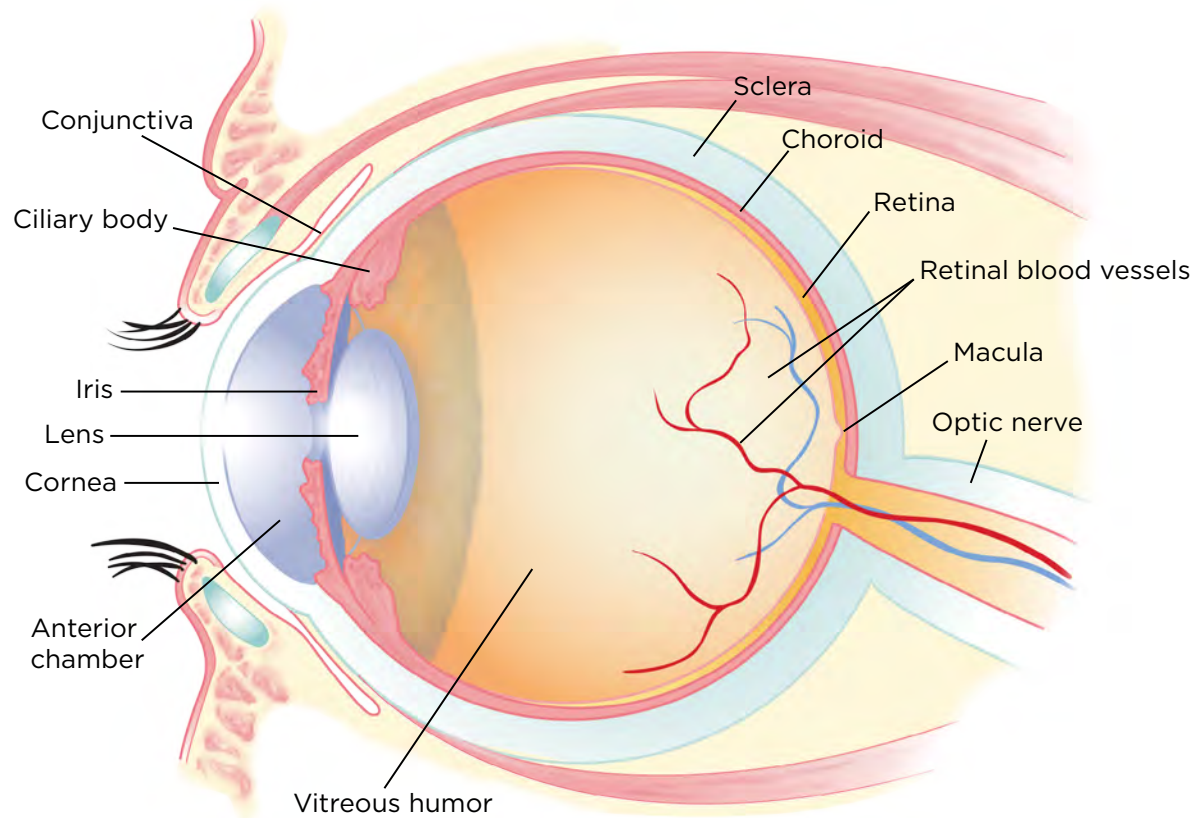
Retinoblastoma (REH-tin-oh-blast-OH-ma) is a cancer of one or both eyes which occurs in young children; it is the most common primary cancer of the eye worldwide. There are approximately 350 newly diagnosed cases per year in the United States. Retinoblastoma affects children of all races, boys and girls equally. The average age for diagnosis is 2.5 years when one eye is involved and 1 year when both eyes are involved.

Retinoblastoma develops in the retina, the light-sensitive layer of the eye which enables the eye to see. If retinoblastoma occurs in only one eye, it is called **unilateral** retinoblastoma, and if it occurs in both eyes it is called **bilateral** retinoblastoma. Most cases (75%) involve only one eye (unilateral), and the rest (25%) affect both eyes (bilateral). The majority (90%) of patients have no family history of the disease, and only a small percentage (10%) have other family members with retinoblastoma.

This booklet will help you understand the eye and the diagnosis and treatment of retinoblastoma.

Structure & Function of the Eye

The eye of an adult measures about one inch from the front to the back of the eye. A child's eye measures about three-quarters of one inch.



The eye has three layers:

- **Sclera** - the outer protective white coating of the eye
- **Choroid** - the middle layer which contains blood vessels to nourish the eye
- **Retina** - the inner layer which contains the nerves that bring information to the brain for seeing. This is where a retinoblastoma starts.

The **cornea** is the clear portion of the front of the eye. The **conjunctiva** is a tissue which lines the eyelids and the eyeball up to the edge of the cornea. The **iris** is the colored portion of the eye. It is made up of a spongy tissue and is an extension of the choroid. The **pupil** is the opening in the iris which allows light into the eye. The **lens** helps focus light rays onto the retina. The lens can change shape, or “accommodate,” to focus on near or distant objects.

The eye is filled with fluids which help nourish and maintain the pressure within the eye. The **anterior chamber**, the front portion of the eye between the iris and the cornea, is filled with aqueous humor, a watery fluid, which nourishes the lens and maintains the pressure within the eye. The back portion of the eye is filled with **vitreous humor**, a transparent gel. The **retina** is made up of ten layers and contains millions of cells. The optic nerve has nerve fibers which transmit information to the brain for interpretation of objects seen and contains about a million cells.

The **macula** is the area of the retina that is responsible for central vision. Its central portion is referred to as the **fovea** and is responsible for the sharpest vision. The macula houses the highest concentration of the cones which are responsible for color and sharp vision. The rest of the retina is composed of rods, which are more sensitive to light and are responsible for night vision and peripheral vision.

Attached to the outside of the wall of the eye are six muscles that aid in the movement of the eye. Movement of the eye is caused by shortening of the eye muscles.

Signs & Symptoms



Retinoblastoma may be discovered during a routine exam by a pediatrician; however, most often the parent is the first one to notice signs of retinoblastoma. For the majority of children with retinoblastoma, the sign that is noticed is a white pupil reflex or **leukocoria**. Leukocoria causes the pupil of the eye to reflect white, as pictured, instead of the normal black (or normal red reflection in a flash photograph).

Other eye diseases can also cause this white pupil reflex, so leukocoria does not always indicate retinoblastoma. An ophthalmologist can determine the correct diagnosis.

A crossed eye or **strabismus** is the second most common sign of retinoblastoma. The child's eye may turn outward (towards the ear) or inward (towards the nose).

Retinoblastoma may also be noticed because of a red painful eye, poor vision, inflammation of the tissue around the eye, an enlarged (dilated) pupil, or a different colored iris. Retinoblastoma may cause other symptoms, like a sudden decrease in eating or drinking.

Genetics

How can retinoblastoma be inherited?

All people, whether they have retinoblastoma or not, have two copies of the retinoblastoma gene called *RB1*. An alteration (mutation) in both copies of the *RB1* gene can cause retinoblastoma tumors. Retinoblastoma mutations can be inherited or can happen by chance.

Inherited retinoblastoma:

In some cases (10%) of the inherited form of retinoblastoma, a mutated copy of the retinoblastoma gene is passed down from a parent to a child.

In other cases, a new retinoblastoma gene mutation may occur by chance at a very early stage in a child's development.

Both types of inherited retinoblastoma are called hereditary retinoblastoma and the retinoblastoma gene mutation is expected to be present in all or most cells of the child's body - including all of the retinal cells.

Non-inherited retinoblastoma:

Most often (90% of the time) retinoblastoma happens by chance and is not inherited. In the non-inherited form of retinoblastoma (sometimes called sporadic form), new retinoblastoma gene mutations occur by chance within a single retinal cell in that child.

What is the chance of inheriting a gene mutation that may cause retinoblastoma?

Both men and women can pass down a retinoblastoma gene mutation. If either parent carries the hereditary mutation, there is a 50% chance (1 in 2) of passing the altered *RB1* gene to each future pregnancy. Roughly 90% of children who inherit a mutated *RB1* gene will develop retinoblastoma.

If bilateral tumors are present (both eyes affected), it is assumed the child has a hereditary form of retinoblastoma. Only about 15% of children with a tumor in one eye, and no family history of retinoblastoma, have the hereditary form. It is possible for a person who has never been treated for retinoblastoma to have a hereditary predisposition (to have an *RB1* gene mutation in all cells of the body). 1 in 200 people who carry a hereditary *RB1 gene mutation*, never develop eye tumors. For this reason, parents of a child with retinoblastoma should have detailed retinal eye exams with an ophthalmologist to look for the presence of a cured or limited retinoblastoma, called a retinoma. Each child of an unaffected parent with a retinoma has a 45% chance of being affected.

Rare situations can occur where the genetic status of a person's germ cells (sperm or egg cells) differ from other parts of the body. This is called germline mosaicism. In one example of this, it is possible that a child with retinoblastoma may have an unaffected parent who tests negative for the *RB1* gene mutation, but has siblings who also develop the disease.

Genetic Testing

How are retinoblastoma gene mutations detected?

Genetic testing may help a family to determine whether a child's personal history of retinoblastoma was inherited or non-inherited.

The best way to test for *RB1* gene mutations is by studying tissue from the retinoblastoma tumor. It is also possible to study a blood sample from someone who has a history of retinoblastoma.

If a hereditary mutation in the *RB1* gene is found, it is possible to look for the same mutation in other family members, even if they have never been affected with retinoblastoma. It is also possible to look for this mutation during a pregnancy before the baby is born, either through a procedure called chorionic villus sampling (CVS) or an amniocentesis. Additionally, it is possible to look for a known *RB1* gene mutation prior to a pregnancy through a fertility technology called pre-implantation genetic diagnosis (PGD). PGD may be an option for families wishing to have future children who will not inherit the altered *RB1* gene, and therefore not inherit the increased cancer risk. To learn more, you can ask for a referral to a fertility specialist prior to pregnancy.

What should my family expect when meeting with a genetic counselor?

Genetic counseling is recommended for all families with a history of retinoblastoma. The initial visit may take place in either the retinoblastoma clinic, or the genetics clinic.

During an initial visit, the genetic counselor will ask questions about your child's diagnosis, as well as elicit details regarding family history of eye disease and other types of cancer. You can expect to discuss the benefits, limitations and risks associated with genetic testing for retinoblastoma. You will also have the opportunity to discuss:

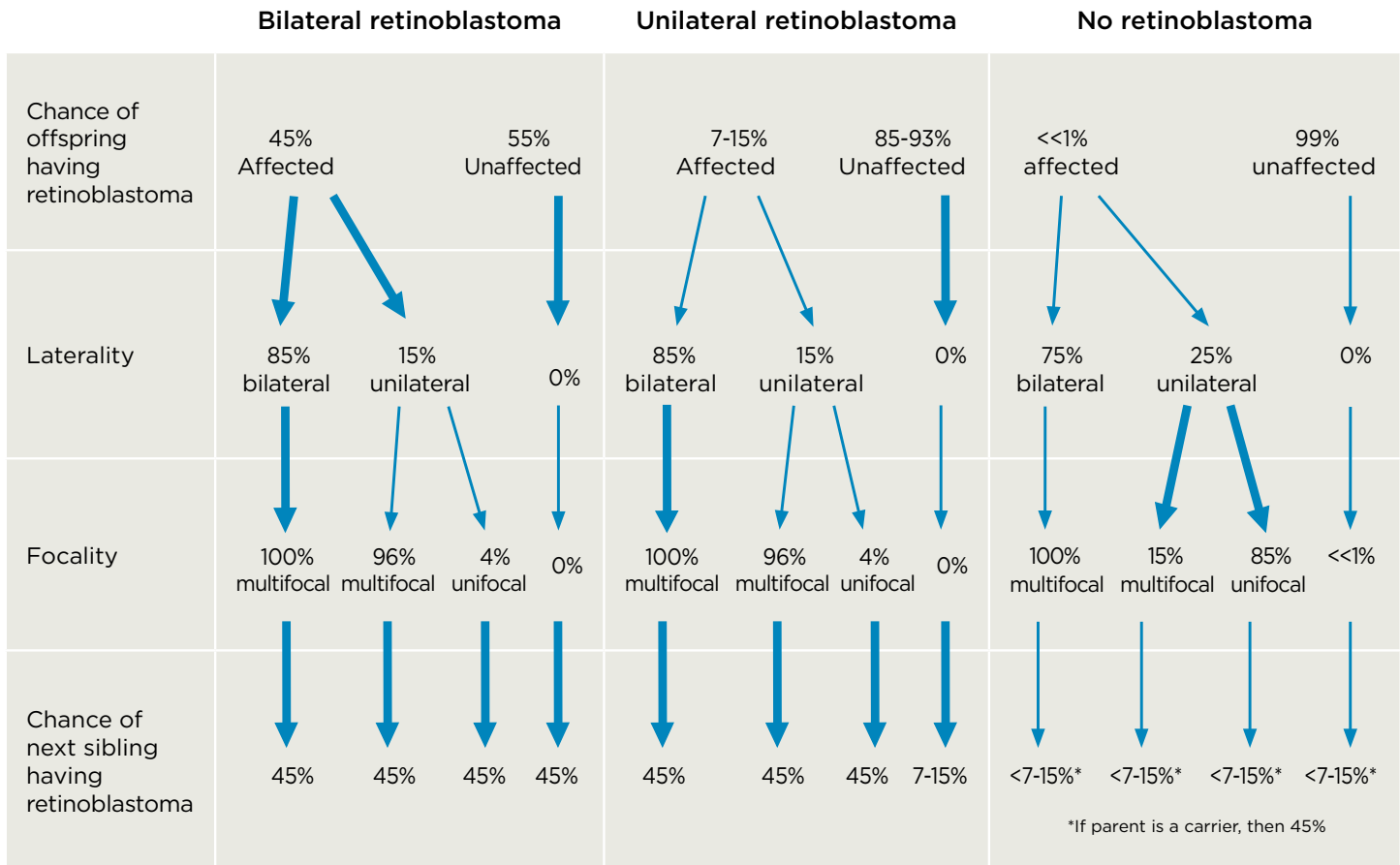
- Cancer risk assessment
- Possible outcomes: positive, negative and uncertain results
- Hereditary retinoblastoma screening recommendations and referrals
- Options for reproductive planning based on genetic test results
- Questions you may have about the genetic test, including insurance coverage, or about retinoblastoma in general

If genetic testing is elected, written consent is obtained from a parent/legal guardian and a blood draw will be coordinated for that day, or a future date. (There are no eating or drinking restrictions prior to the blood draw for genetics). Testing of the *RB1* gene is comprehensive and can take between 6-10 weeks. The genetics service will contact you once the test result is available to schedule an in-person review.

Genetic testing is of course optional and the decision to undergo testing is a personal choice that can be made at the time of the counseling appointment or at a future date.

Genetic Counseling

If Parent Had...



This chart shows the likelihood of a parent to give the retinoblastoma to a child. A reference card explaining this and other important information may be available at your doctor's office.

Examination Schedule for Children Who Have a Family History of Retinoblastoma

First Examination

When: Within 24-48 hours of birth
Where: Newborn Nursery
By Whom: Ophthalmologist at your hospital: Contact pediatrician for referral
How: Dilated exam

Follow-up Examinations

Second Examination:	at 3 weeks of age	
Third Examination:	at 6 weeks of age	
Fourth Examination:	at 10 weeks of age	
Fifth Examination:	at 16 weeks of age	(4 months)
Sixth Examination:	at 24 weeks of age	(6 months)
Seventh Examination:	at 34 weeks of age	(8 months)
Eighth Examination:	at 44 weeks of age	(11 months)
Ninth Examination:	at 54 weeks of age	(1 year, 1 month)
Tenth Examination:	at 66 weeks of age	(1 year, 3 months)
Eleventh Examination:	at 78 weeks of age	(1 year, 6 months)
Twelfth Examination:	at 90 weeks of age	(1 year, 9 months)
Thirteenth Exam:	at 102 weeks of age	(1 year, 11 months)
Fourteenth Exam:	at 114 weeks of age	(2 year, 2 months)

This chart shows the examination schedule for children when one parent has retinoblastoma.



Facts

Worldwide

- 50% of retinoblastoma patients will die each year

In the United States

- More than 95% of children treated for retinoblastoma are cured of the cancer
- More than 90% of patients retain at least one eye
- More than 90% of children retain normal vision in at least one eye
- Complete blindness is unusual in children who have been successfully treated for retinoblastoma
- Retinoblastoma is the seventh most common childhood cancer
- 350 children are diagnosed with retinoblastoma each year

At Memorial Sloan Kettering Cancer Center

- More than 99% of patients treated for retinoblastoma are cured of the cancer

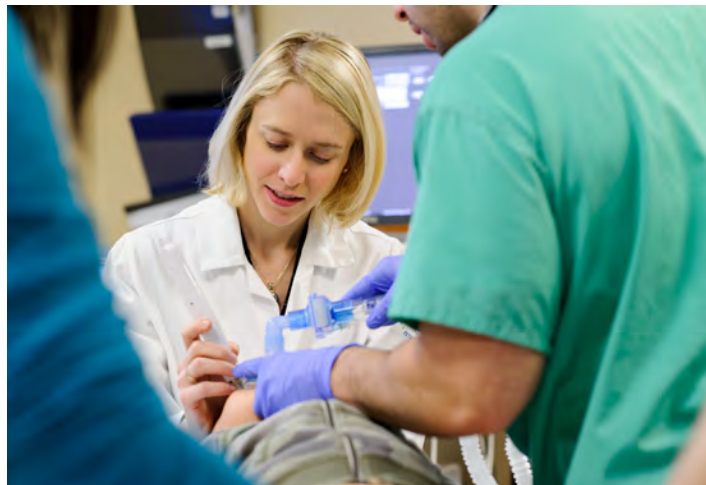
Diagnosis

If there is a family history of retinoblastoma, newborn babies should be examined in the nursery at birth by an ophthalmologist (an eye doctor). When there is no family history, it is frequently the parents who notice leukocoria or strabismus and bring the child in for an examination. Often the general ophthalmologist refers the child to an ophthalmologist who specializes in children with retinoblastoma and other cancers of the eye.

At MSK, examinations are done under general anesthesia by an ophthalmologist in our retinoblastoma clinic. This is the best and most thorough way to diagnose your child. In order to minimize the risks of anesthesia, the nurse will ask that your child not be given food or fluids for several hours before the examination. The parent will receive specific instructions depending on the child's age prior to your appointment. Parents are allowed and encouraged to be with their children in the procedure room until the child is safely under anesthesia.

If you have any concerns or questions about whether your child should receive anesthesia, you should speak to the ophthalmologist, nurse, or anesthesiologist prior to your appointment date.

Examinations without anesthesia can usually be done for older patients who are not on active treatment and for children with a family history of retinoblastoma, getting routine screening.

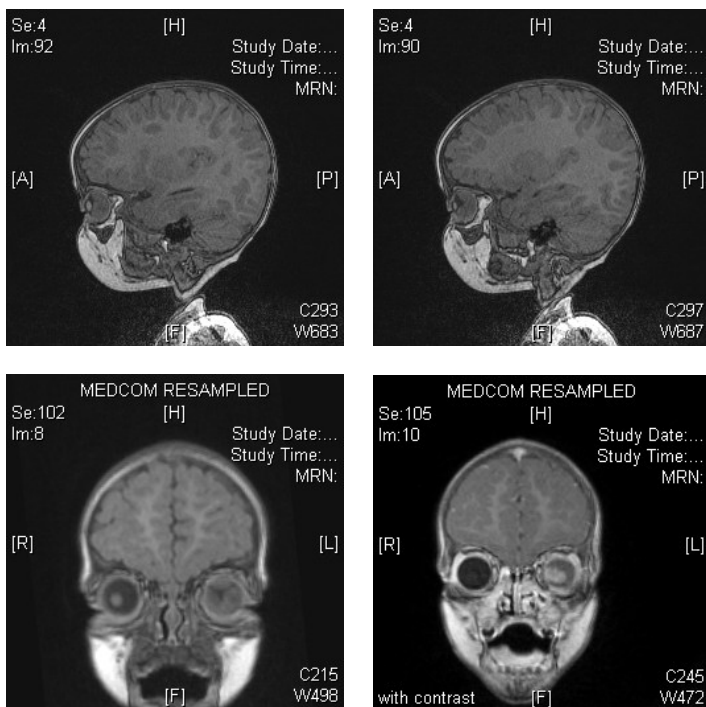


MRI

MRI of the head is performed if a diagnosis of retinoblastoma is made. The purpose of this test is to confirm the diagnosis of retinoblastoma and to check if the tumors are contained to the eye/eyes or if there has been any spread to the brain. This can be seen in advanced cases of retinoblastoma and would require a consultation with our pediatric oncologist for more possible diagnostic testing and more advanced treatment. MRI is usually repeated yearly after diagnosis is made.

Children typically require anesthesia during MRI scanning and this can be easily arranged by our nurses. MRI can be done without anesthesia for older children starting at the age of 5-6. Our child life therapist can work with your child during their MRI.

MRI has no X-rays and does not expose your child to ionizing radiation. MRI is usually done with and without contrast so please discuss any allergies with the nurses prior to scheduling an MRI. Results are usually available 24-48 hours after the MRI is complete. Your ophthalmologist will discuss results of the MRI.



MRI Scan of Retinoblastoma

Diagnostic Facts:

- Retinoblastoma is diagnosed by direct viewing of the tumors inside the eye, ultrasound, Ret Cam images, and MRI scans.
- Biopsies are rarely necessary.
- Anesthesia for examination and treatment may be necessary as often as every 3-4 weeks.
- Examination of the parents may help in the diagnosis of the child.
- If retinoblastoma is diagnosed, the child's siblings should be examined.

What to expect on the day of your visit



Before the exam

Upon arrival to our retinoblastoma clinic, you and your child will meet the nurses who will obtain a brief history, do an eye assessment, and begin to prepare your child for the examination under anesthesia. The nurses will put a set of dilating drops into your child's eyes. These drops make the pupil get larger, so the doctors can see into the eye and make a diagnosis. You will then meet with the ophthalmologist to go over any questions you have before the examination under anesthesia.

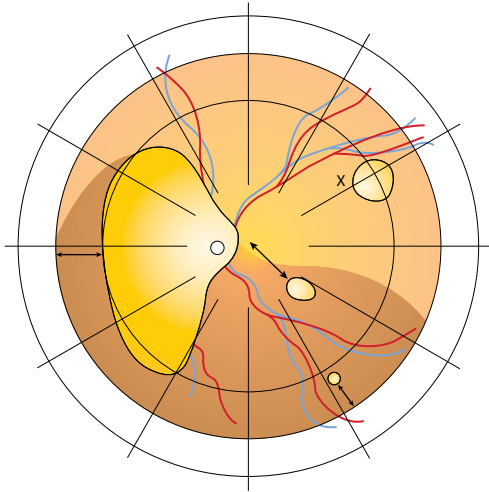
Next, you and your child will be taken to the procedure room, and your child will be given general anesthesia. Anesthesia is given through a small colored, scented mask that will be placed over your child's nose and mouth until he/she falls asleep. The child will usually fall asleep within a minute. You are encouraged to stay with your child until he or she is asleep. You will then be taken to a waiting area while the exam is performed.

During the exam

During the examination, the ophthalmologist will carefully examine both eyes to look for tumors or abnormalities. First, the doctor places a metal clip, called a lid speculum, between the eyelids to help keep the child's eye open. Because the child is under anesthesia and his or her eye is numbed, this clip does not cause any discomfort. Blood may be drawn for blood tests, and an intravenous line may be placed if the ophthalmologist anticipates beginning treatment while the child is under anesthesia.

To assess your child's eyes for tumors, the doctor may use:

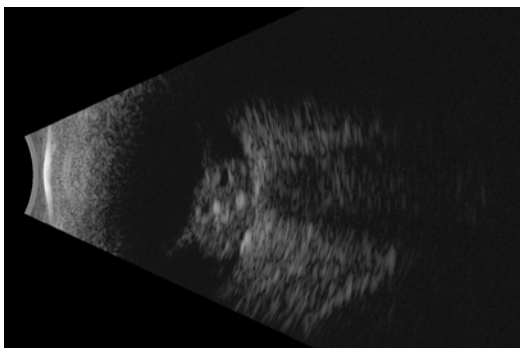
- An ophthalmoscope to view the retina.
- Retinal drawings. These drawings are done by most ophthalmologists and can be interpreted worldwide.
- Photography (RetCam images). These photographs, along with retinal drawings, serve as maps for the tumor(s). Future examinations will be based on these original drawings and photographs.
- Ultrasound, which uses sound waves to penetrate and outline structures in the eye. Ultrasound confirms the presence of any retinoblastoma tumors and determines their thickness or height.
- Eye pressure measurement.
- Electroretinography, which measures the electrical activity of the retina.



Retinal drawing of retinoblastoma



RetCam image of retinoblastoma



Ultrasound of retinoblastoma

The results of all these tests will be available immediately after the exam.

The child will be monitored throughout the exam until he or she recovers. The exam takes around 20-30 minutes.

After the exam

When the exam is complete, your child will be moved to a recovery area. Meanwhile, the doctor will discuss the examination results with you. The doctor will also discuss treatment options and follow-up. You will have ample time for discussion and questions.

When your child is awake, he or she will be brought out by the pediatric recovery nurse. A common side effect of anesthesia is irritability for about 10-15 minutes. Additionally, some children may experience nausea and/or vomiting. The child will be able to drink and eat small amounts shortly after recovery. Discharge instructions will be given and the child will be discharged home the same day.



Classification

The severity of retinoblastoma tumors may be classified by either of two systems: the Reese-Ellsworth classification system and the International Classification. The higher the Group number or letter in the system, the poorer the prognosis is for saving the eye. Some centers may use one classification over the other, but at MSK we use both.

Reese-Ellsworth Classification for Retinoblastoma

This classification system was developed as a method to predict whether the child's eye can be saved.

GROUP I

- A. Solitary tumor, less than 4 disc diameters in size, at or behind the equator.
- B. Multiple size tumors, none over 4 disc diameters in size, all at or behind the equator.

GROUP II

- A. Solitary tumor, 4 to 10 disc diameters in size, at or behind the equator
- B. Multiple size tumors, 4 to 10 disc diameters in size, all at or behind the equator

GROUP III

- A. Any lesion anterior to the equator.
- B. Solitary tumors larger than 10 disc diameters behind the equator.

GROUP IV

- A. Multiple tumors, some larger than 10 disc diameters
- B. Any lesion extending anteriorly to the ora serrata

GROUP V

- A. Massive tumors involving over half of the retina
- B. Vitreous seeding.

International Classification

GROUP A

- Small tumors (less than 3 mm) that are only in the retina and more than 3 mm away from the foveola (the center of the fovea) and more than 1.5 mm away from the optic disk.

GROUP B

- Tumors larger than 3 mm that are confined to the retina in any location.
- Clear subretinal fluid less than 6 mm from the edge of the tumor.

GROUP C

- Localized vitreous and/or subretinal seeding (less than 6 mm from the tumor margin).
- No tumor masses, clumps or snowballs in vitreous or in the subretinal space.

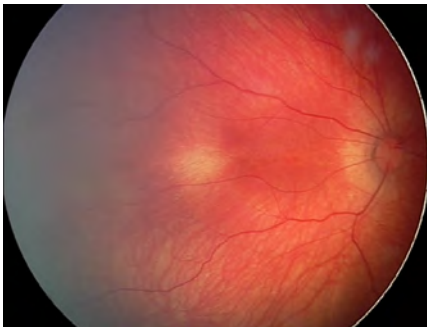
GROUP D

- Diffuse vitreous and/or subretinal seeding (more than 6 mm from tumor).
- Subretinal fluid more than 6 mm from tumor margin.

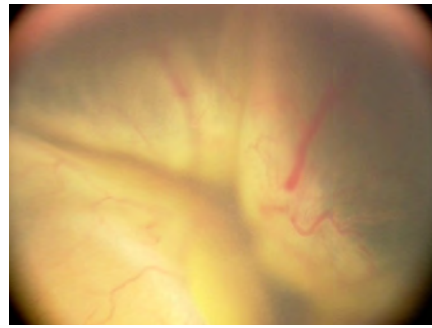
GROUP E

- No visual potential OR presence of one or more of the following:
 - Tumor in the anterior segment
 - Tumor in or on the ciliary body
 - Neovascular glaucoma
 - Vitreous hemorrhage obscuring the tumor or significant hyphema
 - Phthisical or pre-phthisical eye
 - Orbital cellulitis-like presentation

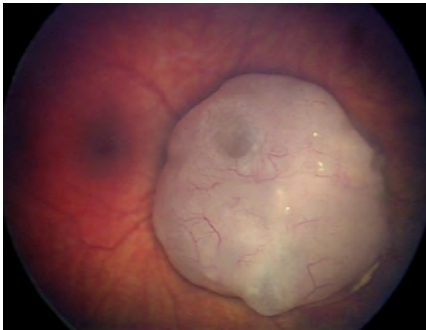
GROUP A



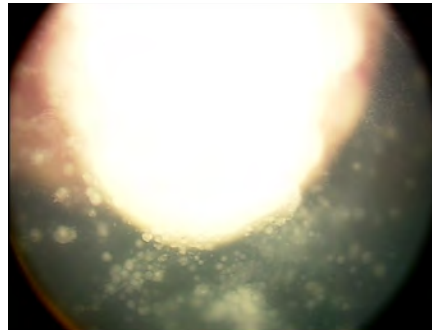
GROUP D



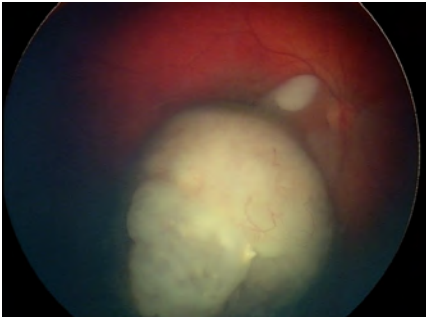
GROUP B



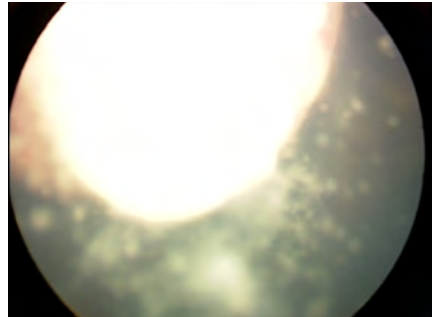
GROUP E



GROUP C



GROUP E



Treatment

The treatment of retinoblastoma is individualized for each patient. The treatment depends on the age of the child, the involvement of one or both eyes, and the characteristics of each tumor. Almost all parents choose some form of treatment for their child. Retinoblastoma is a very curable disease, but it is always deadly if left untreated.

Ophthalmic artery chemosurgery (OAC): OAC (sometimes called intra-arterial chemotherapy) is a method of going through the ophthalmic artery to deliver small amounts of chemotherapy directly to the cancer in the eye itself. OAC was first performed in 2006 at MSK and New York Presbyterian Hospital by Drs. David Abramson and Pierre Gobin. Since then, we have used OAC more than 1500 times, treating more than 450 eyes. This is a large number, since there are only 350 cases of retinoblastoma per year in the entire country.

OAC is done on an outpatient basis by an interventional radiologist. The radiologist threads a tiny catheter through the femoral artery (the artery near the groin) and feeds the catheter up to the ophthalmic artery itself. Once the catheter is in place, the radiologist injects a small amount of chemotherapy directly into the one blood vessel that supplies the eye. This procedure is unique in that it enables us to apply the drugs in high concentration to the cancer. Typically treatments are given monthly for an average of 3 to 4 times. OAC alone can sometimes cure the cancer.

OAC has become the standard of care for patients with retinoblastoma at MSK. This procedure is now used in more than 32 countries.

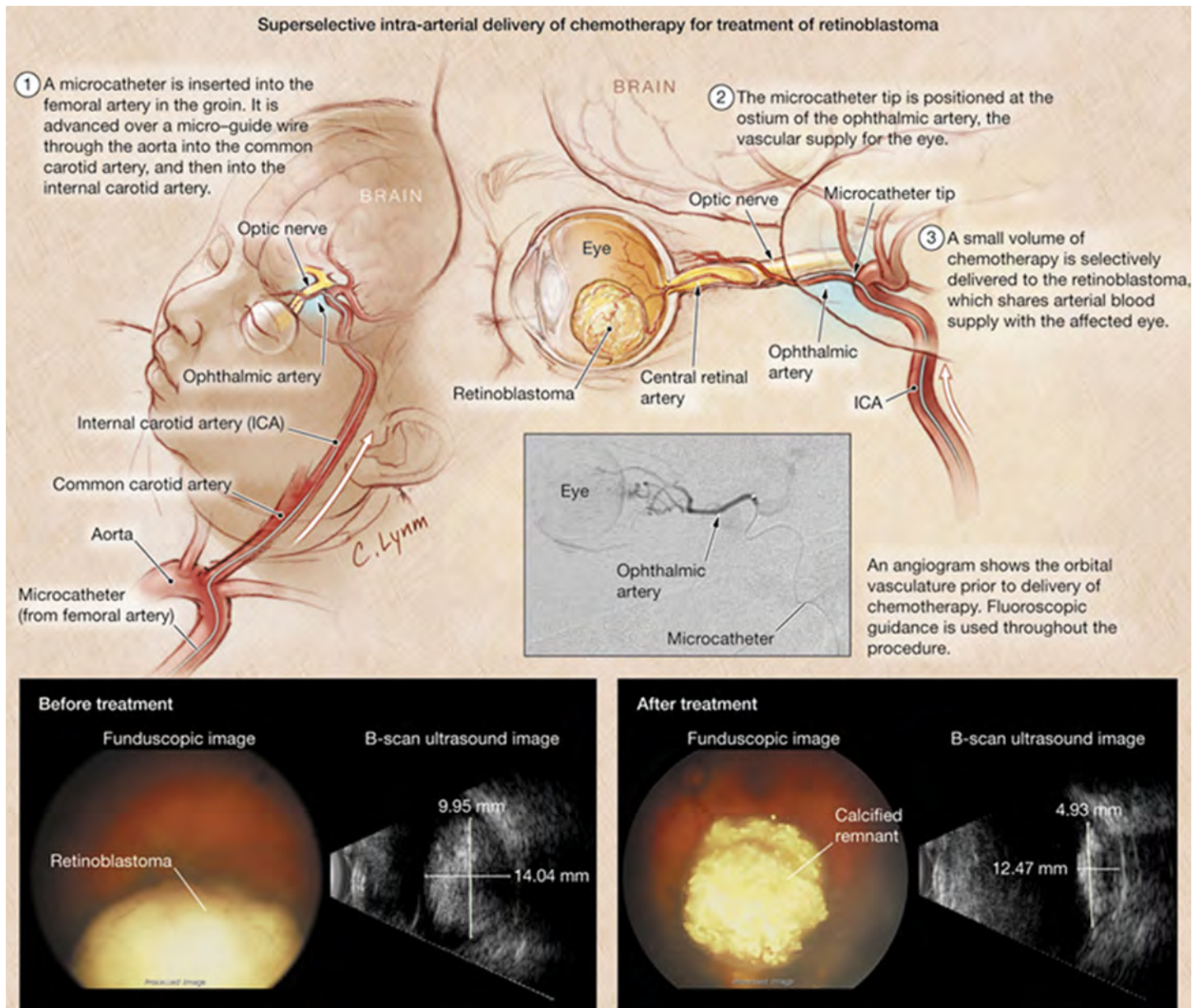
Unlike with traditional systemic intravenous chemotherapy, ophthalmic artery chemosurgery does not require the patient to have a central line inserted. Children who receive OAC experience significantly less side effects than children treated with systemic chemotherapy. OAC can cause mild neutropenia (a reduction in the numbers of white blood cells) and localized swelling, redness, and sometimes mild discomfort for a few days. Less than 1% of children treated with OAC need blood transfusions.

Intravitreal chemotherapy involves injecting a tiny amount of chemotherapy through the wall of the eye and into the vitreous. The procedure is done on an outpatient basis while the child is under anesthesia. Treatments are typically given monthly for an average of 3-4 times. These treatments do not typically cause any pain, although the white part of the eye may sometimes appear red for a couple of days.

Intravitreal chemotherapy is particularly useful at treating vitreous seeds, which are little fragments of tumor that break off and float in the jelly (vitreous) of the eye. Occasionally this method may be combined with periocular chemotherapy.

Periocular chemotherapy: Periocular chemotherapy is a method of injecting chemotherapy under one of the layers of tissue that surround the eye. The needle does not enter the eye. Instead, the chemotherapy bathes the outside of the eye and passes through the wall and into the eye. This treatment may be given along with other therapies (ophthalmic artery chemosurgery or intravitreal chemotherapy). Patients may experience mild swelling and redness of their eye and eyelids for a couple of days.

Ophthalmic artery chemosurgery



JAMA 305(22):2276-2278. © American Medical Association

Laser therapy is a non-invasive treatment for retinoblastoma. As shown in the photograph, it can be performed on an outpatient basis during your child's exam under anesthesia. Laser therapy is very effective in destroying small retinoblastoma tumors and can also be used in conjunction with other treatment options to control larger tumors. This type of treatment is usually done by focusing an invisible light through the pupil, into and around the tumors. The light slowly heats up the tumor, destroying it. Laser therapy does not usually cause any pain after the procedure.

Cryotherapy is another treatment which is performed on an outpatient basis during your child's exam under anesthesia. Cryotherapy freezes small retinoblastoma tumors and can also be used in conjunction with other treatment options to control bigger retinoblastoma tumors. A pen-like probe is gently placed on the sclera next to the tumor and the tumor is frozen. Cryotherapy may have to be repeated several times to destroy all of the cancer cells. Cryotherapy may cause the eyelid to swell for 1-5 days, and sometimes the swelling can cause the eyelid to swell closed. This can be frightening for the child and parents but is usually harmless and will go away in a few days. The child can be given eye drops or ointment to reduce the swelling and pain medication if necessary.



Laser treatment for retinoblastoma



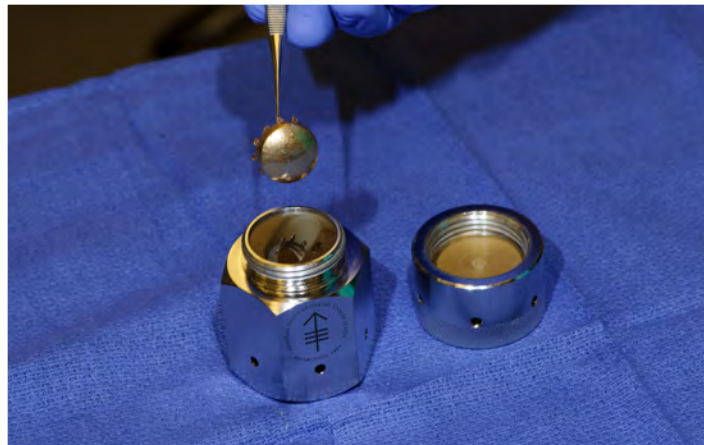
Cryotherapy treatment

Systemic Chemotherapy (Chemoreduction):

In this technique, a chemotherapy drug is given intravenously or through a central line. The drug goes into the bloodstream, and as it passes through the eye, it causes the tumors to shrink, a process called chemoreduction. While systemic chemotherapy can be effective at shrinking the tumors, it rarely cures retinoblastoma on its own.

Patients who will receive chemotherapy will be treated by a pediatric oncologist, who will monitor the chemotherapy dose and any side effects in our Pediatric Day Hospital. At MSK, chemoreduction is used mainly for small infants until they are big enough to receive ophthalmic artery chemosurgery. In that case, the child receives only a small dose of chemotherapy to control the tumors until he or she is three months old and or weighs 6 kg or more.

Radioactive Plaques are discs that give off radiation to kill the cells in a retinoblastoma tumor. They were developed in the 1930's. The plaques are custom-made for each child. The child must be hospitalized and undergo two operations: the first to insert the plaque and the second, 1-4 days later, to remove the plaque. The small radiation disc is surgically placed on the eye to destroy the retinoblastoma tumor(s). After the surgery, patients take eye drops or ointment for 3-4 weeks to prevent infection and inflammation. The long-term side effects may include cataracts, radiation retinopathy (breakdown of the retina, causing bleeding and exudate of retina), and impaired vision.

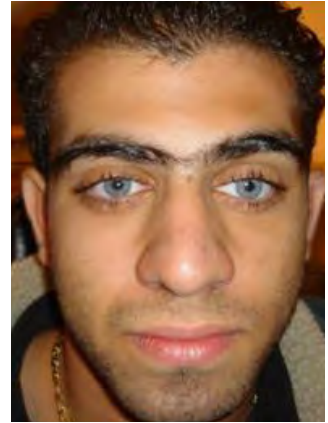


Radioactive plaque

Enucleation is a surgical removal of the eye itself. Since ophthalmic artery chemosurgery was developed, the need for enucleation has dramatically reduced. Nonetheless, enucleation is still a good treatment option for retinoblastoma that is too advanced for ophthalmic artery chemosurgery. With enucleation, the eye is completely removed. Complete removal of the eye is the only way to remove the cancer from the body. It is impossible to surgically remove the cancer and leave the eye.

Enucleation is done under general anesthesia (the child is completely asleep) in the operating room. Parents may be able to accompany their child into the operating room on the day of surgery. The surgery removes the entire eye along with a long piece of the optic nerve. The eyebrow, lids, and muscles of the eye are all left in place, so the child will still be able to blink, form tears, and move his or her brow.

Can you tell which is the prosthetic eye?



Before the procedure, the physician, in the presence of the family, will mark his or her initials over the eye to have surgery. This ensures that the correct eye will be removed. The operation takes less than an hour and is not painful. A ball of plastic rubber or coral is placed where the eye had been so there is no cavity or hole. Children go home the same day; you will receive instructions on how to care for the site.

After the eye socket heals, it will look like the tissue on the inside of the lip. The child can be fitted for a prosthesis (a false eye) approximately 4-6 weeks after the operation. The prosthesis is made of plastic by an ocularist (an artist/technician) to look exactly like the other eye. Since the muscles around the eye are not attached to the prosthesis, it does not move as well as the natural eye. The prosthetic eye tends to move better up and down than it does side to side. There is currently no way to transplant or replace an entire eye.

External Beam Radiation Therapy (EBRT) has been used since the early 1900's as a way to treat retinoblastoma while saving the eye(s) and vision. Retinoblastoma is sensitive to radiation, and fortunately retinoblastoma (unlike most other cancers) can be permanently cured with radiation. Even though thousands of children with retinoblastoma have been cured with radiation therapy, it is used less often today because it may have long-term side effects and because safer treatments, like ophthalmic artery chemosurgery, are available. Side effects of EBRT are most likely to occur in those who were treated in their first year of life and in those who have the genetic form of retinoblastoma.

Coping

Note from the nurses:

It is okay to feel frightened, overwhelmed, and anxious. This is a normal, common reaction to the diagnosis of retinoblastoma in your child. Our nurses, who are certified in pediatric oncology, will work together with your family to coordinate your child's treatment plan. They will help you arrange for blood work and other testing and will communicate with your pediatrician or oncologist in the follow-up care required between appointments. The nurses can also speak with your child's teacher and school or camp nurse if issues arise. Please do not hesitate to speak to them about any questions or concerns you may have.

You may also find support by talking to other parents or children in the waiting room. A child life therapist is usually present in our clinic and always available to assist your child in coping with stressful situations. Fortunately, children are remarkably adaptable. Your child may cope better than you!

Resources:

Our social worker can provide emotional support and can help you find resources in the community, like housing and transportation. Ronald McDonald House provides subsidized housing for patients traveling from out of state or country. Charitable flights may also be available for domestic patients. Ask about support groups and one-on-one counseling. A child psychiatrist is available upon request. Many families have found these resources helpful.



Here are some websites that you may find useful:

mskcc.org/search/site/retinoblastoma

mskcc.org/blog/meet-retinoblastoma-team

eyewiki.aao.org/Intra-arterial_Chemotherapy_for_Retinoblastoma

www.mskcc.org/blog/large-study-retinoblastoma-survivors-identifies-extent-medical-conditions-later-life

www.miraflexglasses.com

www.funooogles.com

Long-term consequences



The majority of children in the US (over 95%) survive the cancer and go on to live normal lives. Children with retinoblastoma can have normal vision, play sports, and later drive cars. They go to regular schools, have careers, and have families themselves.

It is extremely important for children who have an enucleation to wear protective eyewear lifelong to protect their remaining eye. We encourage full-time protective glasses, especially when participating in sports and other potentially hazardous activities. You do not need a prescription to get protective lenses, but you can get one from your ophthalmologist.

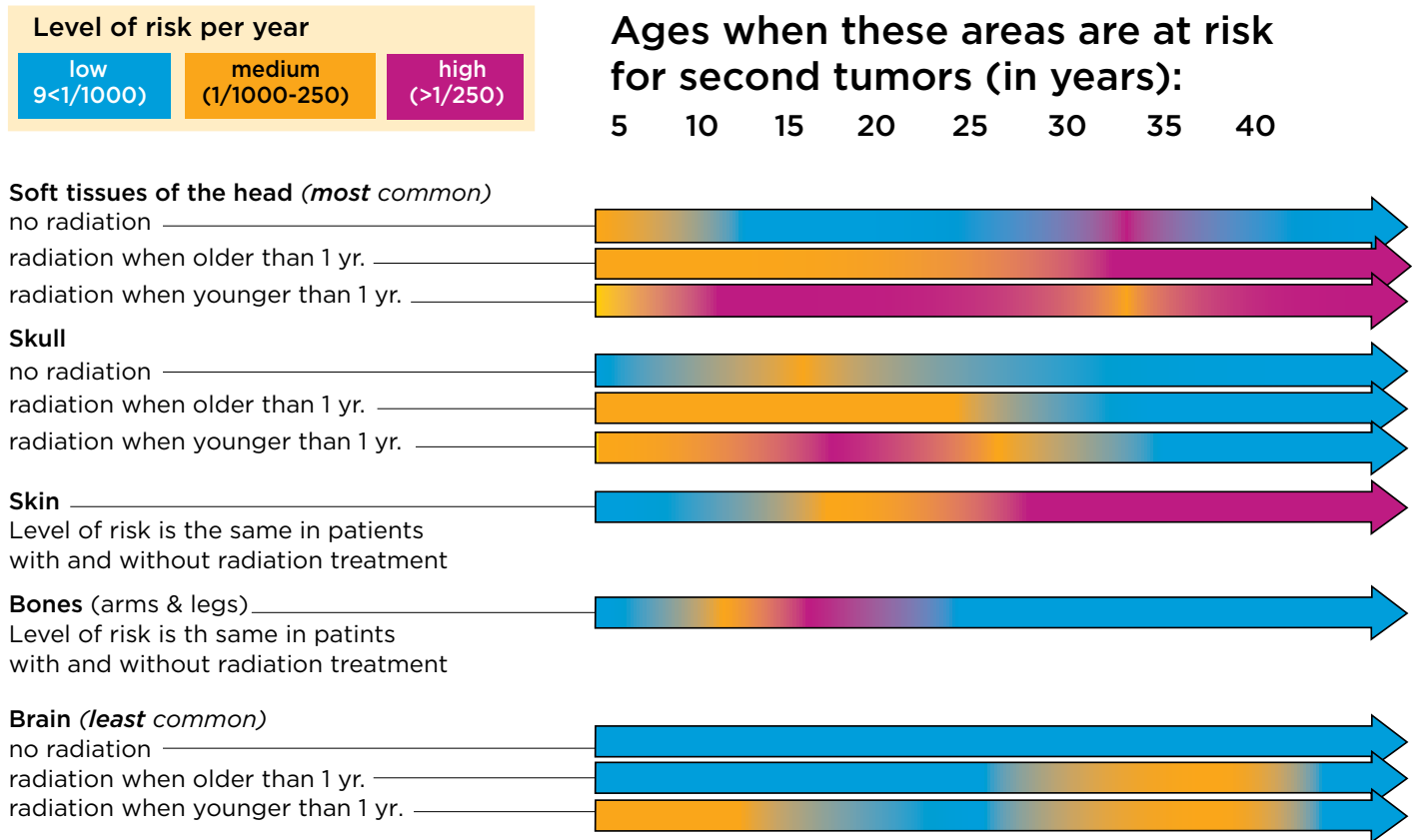
It is especially important for children to have lifelong follow-up with an ophthalmologist to detect potential consequences of the disease and treatment.

Studies demonstrate that children with the non-hereditary form of retinoblastoma are NOT at increased risk for second cancers. However, children with the hereditary form of retinoblastoma are at higher risk for second cancers in locations outside the eyes. Close follow-up is especially important because the second cancer might be life-threatening. We highly encourage diagnostic testing, such as yearly MRI scans. Many hospitals, including ours, have long-term follow-up clinics. Discuss this with your ophthalmologist.

The most common second tumors are osteogenic sarcomas (a tumor which affects the bone), soft tissue sarcomas, and cutaneous melanomas (tumors of the skin, muscle, and connective tissues). Although the risk of these tumors varies widely in different studies, the risk appears to be about 1% per year.

Retinoblastoma is life-threatening, but it is rarely fatal if treated appropriately. With the correct treatment, an experienced ophthalmologist, and appropriate follow-up, the patient with retinoblastoma has a very good chance of living a long, full, and happy life.

This chart shows the ages when parents and patients need to be aware of potential secondary cancers. The chart is based on statistical analysis of patients who were diagnosed with retinoblastoma over a period of more than 40 years.



A reference card explaining this and other important information may be available at your doctor's office.

Glossary of Terms

Aqueous Humor – watery fluid which bathes and nourishes the front of the eye

Bilateral Retinoblastoma – cancerous tumor(s) in the retina of both eyes

MRI (magnetic resonance imaging) – a test which uses a magnetic field and radio waves to create detailed images to view the eye and brain with no radiation exposure

Choroid – the middle layer of the eye which contains blood vessels

Chromosome 13 – the chromosome which has a missing piece that is responsible for the development of retinoblastoma

Conjunctiva – this membrane which lines the outside of the eye

Cornea – clear portion of the front of the eye which bends light rays

Cryotherapy – freezing treatment for small retinoblastoma tumor(s)

Disc diameter – horizontal size of the optic nerve head approximately 1-1.5 mm used as a reference point to measure tumors

Enucleation – surgical removal of the eye

Equator – a circular reference zone approximately half way between the back of the eye and the front of the eye

Vitreous – jelly like substance that fills the eye

ERG (Electroretinography) – Measurement of the electrical activity of the retina (similar to an EKG of the heart), which serves as a proxy for visual function.

External Beam Radiation – treatment which uses machines to give radiation to treat the tumors

Fundus Drawings – map of the eye with tumor sketches drawn by the ophthalmologist

Fundus Photographs – a photograph of the inside of the eye showing the retina

Indirect Ophthalmoscope – instrument used to view the retina

Ophthalmic Artery Chemosurgery (OAC) – a localized treatment designed to deliver chemotherapy directly into a tumor with minimal harmful impact on other body systems.

Peri-ocular injection – injection of medicine under one of the layers that surrounds the eye

Intra-vitreous injection – injection of medicine through the wall of the eye into the vitreous

Iris – the colored portion of the eye

Lamina cribrosa – the zone in the optic nerve which represents the anatomical end of the eye

Laser – light therapy used to treat small retinoblastoma tumor(s)

References

- Abramson DH. Retinoblastoma: saving life with vision. *Annual Review of Medicine*. 2014;65:171-84.
- Abramson D. Benefits and risks of intra-arterial chemotherapy for retinoblastoma, an update. *Retina Today*. 2011;6(8):43-6.
- Abramson DH. Chemosurgery for retinoblastoma: what we know after 5 years. *Archives of Ophthalmology*. 2011;129(11):1492-4.
- Abramson DH, Gobin YP, Dunkel I, Marr BP, Brodie S, Freund KB. Highlighting complications over successes in occurrence of sectoral choroidal occlusive vasculopathy. *Retina (Philadelphia, Pa)*. 2011;31(8):1746; author reply 7-8.
- Abramson DH, Marr BP, Brodie SE, Dunkel I, Palioura S, Gobin YP. Ophthalmic artery chemosurgery for less advanced intraocular retinoblastoma: five year review. *PLoS ONE*. 2012;7(4):e34120.
- Abramson DH, Marr BP, Brodie SE, Dunkel IJ, Lin A, Folberg R, et al. Intraocular hemorrhage after intra-arterial chemotherapy for retinoblastoma in sickle cell trait. *Open Ophthalmology Journal*. 2012;6:1-3.
- Abramson DH, Marr BP, Dunkel IJ, Brodie S, Zabor EC, Driscoll SJ, et al. Intra-arterial chemotherapy for retinoblastoma in eyes with vitreous and/or subretinal seeding: 2-year results. *British Journal of Ophthalmology*. 2012;96(4):499-502.
- Chantada G, Dunkel I, Abramson D. Management of high-risk retinoblastoma. *Expert Review of Ophthalmology*. 2012;7(1):61-72.
- Dryja T. Assessment of risk in hereditary retinoblastoma. In: Albert D, Jakobiec F, editors. *Principles and Practice of Ophthalmology*, vol. 5. Philadelphia: WB Saunders Co.; 1996. p. 3270-9.
- Eng C, Li FP, Abramson DH, Ellsworth RM, Wong FL, Goldman MB, et al. Mortality from second tumors among long-term survivors of retinoblastoma. *Journal of the National Cancer Institute*. 1993;85(14):1121-8.
- Francis JH, Kleinerman RA, Seddon JM, Abramson DH. Increased risk of secondary uterine leiomyosarcoma in hereditary retinoblastoma. *Gynecologic Oncology*. 2012;124(2):254-9.
- Gobin YP, Dunkel IJ, Marr BP, Brodie SE, Abramson DH. Intra-arterial chemotherapy for the management of retinoblastoma: four-year experience. *Archives of Ophthalmology*. 2011;129(6):732-7.
- Gobin YP, Rosenstein LM, Marr BP, Brodie SE, Abramson DH. Radiation exposure during intra-arterial chemotherapy for retinoblastoma. *Archives of Ophthalmology*. 2012;130(3):403-4; author reply 4-5.
- Kleinerman RA, Yu CL, Little MP, Li Y, Abramson D, Seddon J, et al. Variation of second cancer risk by family history of retinoblastoma among long-term survivors. *Journal of Clinical Oncology*. 2012;30(9):950-7.
- Klufas MA, Gobin YP, Marr B, Brodie SE, Dunkel IJ, Abramson DH. Intra-arterial chemotherapy as a treatment for intraocular retinoblastoma: alternatives to direct ophthalmic artery catheterization. *AJNR American Journal of Neuroradiology*. 2012;33(8):1608-14.
- Mills MB, Hudgins L, Balise RR, Abramson DH, Kleinerman RA. Mutation risk associated with paternal and maternal age in a cohort of retinoblastoma survivors. *Human Genetics*. 2012;131(7):1115-22.
- Palioura S, Gobin YP, Brodie SE, Marr BP, Dunkel IJ, Abramson DH. Ophthalmic artery chemosurgery for the management of retinoblastoma in eyes with extensive (>50%) retinal detachment. *Pediatric Blood & Cancer*. 2012;59(5):859-64.



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