1. Introduction

We present the case of a 9 year 4-month-old female patient with a diagnosis of acute lymphoblastic leukemia (ALL). She arrived at the emergency department with fever, vomiting and bowel movements decreased in consistency.

1.1. Family history

The patient’s mother is a 48-year-old housewife diagnosed with hypertension at age 40 and treated with captopril. The patient’s father lives outside the family nucleus. There are two healthy brothers aged 26 and 24 years. Maternal grandparents have a history of type 2 diabetes mellitus.

1.2. Social history

The patient is a native of and resident of the Federal District (Mexico City). The family is of low socioeconomic status. There are all domiciliary services in the home. The patient was exclusively breastfed until 2 months of age and was integrated into the family diet at 7 months of age. Immunizations were complete for age. The patient demonstrated apparently normal psychomotor development and attended school until first grade.

1.3. Perinatal and medical history

The patient was the product of a third gestation with prenatal control from the first month of gestation with placenta previa and retroplacental hematoma. Birth was by cesarean section at 40 weeks gestation with a birth weight of 3 kg. The patient had recurrent lower urinary tract infections and urethral stenosis diagnosed at 3 years of age.

1.4. Current condition

November 2007. The patient presented for the first time to the emergency department of this institution due to fever and abdominal distension of 3 months duration.
The patient presented urinary symptoms. On physical examination, there were petechiae and ecchymoses on the extremities. A bone marrow aspirate (BMA) showed 99% blasts with no myeloblasts. There was no sign of a pre-B immunophenotype. There were no blasts observed in the cerebrospinal fluid (CSF). Chemotherapy was started with vincristine, daunorubicin, L-asparaginase, and dexamethasone. The last dose was received during January 2012.

The patient experienced the first CNS relapse in December 2007. CT of the paranasal sinuses demonstrated left ethmoidal, maxillary, and sphenoidal sinusitis. The patient was managed with amphotericin B. Echocardiogram showed an ejection fraction of 82%. Chest CT scan showed apical consolidation and areas of bilateral pulmonary consolidation. CT of the thorax showed apical pulmonary consolidation and areas of bilateral pulmonary consolidation.

In 2009, a deep focus CT was performed. This radiological study showed a death in remission despite having a diagnosis of ALL. The patient was started on induction therapy with vincristine, daunorubicin, cyclophosphamide, L-asparaginase, and dexamethasone.

The patient was admitted on February 21, 2010, due to fever. The patient was found to be pale, dehydrated, chest with no significant radiological finding in the chest. There was no significant radiological finding in the abdomen, except for 11 cm hepatomegaly. CT scan of the chest showed apical consolidation and areas of bilateral pulmonary consolidation. CT of the thorax showed apical pulmonary consolidation and areas of bilateral pulmonary consolidation.

CT of the spine demonstrated left ethmoidal, maxillary, and sphenoidal sinusitis. The patient was managed with amphotericin B. CT of the paranasal sinuses demonstrated left ethmoidal, maxillary, and sphenoidal sinusitis. The patient was managed with amphotericin B. CT of the paranasal sinuses demonstrated left ethmoidal, maxillary, and sphenoidal sinusitis. The patient was managed with amphotericin B. Echocardiogram showed an ejection fraction of 82%.

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Syndromic diagnoses were as follows:

- Infiltrative syndrome: lymphadenopathy, hepatomegaly, and splenomegaly
- Anemic syndrome: pallor, systolic murmur II/VI, and Hbg 9.1 g/dl
- Hemorrhagic disease syndrome: petechiae, ecchymosis of the extremities, and platelet count of 71,000
- Infectious syndrome: fever, urinary, ear, pulmonary, and abdominal symptomatology

Nosological diagnoses are as follows:

- Normal risk ALL due to the presence of an infiltrative, anemic, and hemorrhagic syndrome, bone marrow aspirate with 99% blasts, age within 1 to 10 years, B-cell precursors, and response to remission induction
- Recurrent urinary tract infection due to the presence of proteinuria, pyuria, microhematuria on urinalysis, presence of *Escherichia coli* in two urine cultures, and urethral stricture
- Neutropenic colitis due to the presence of profound neutropenia, absolute neutrophil of 100/mm$^3$, stools decreased in consistency, and vomiting

ALL is the most common form of cancer in children. It constitutes 30-34% of all diagnosed cases of cancer. Of these, 80% correspond to ALL and the remaining 20% to acute myeloid leukemia (AML).

In the evolution of children with ALL, fever is an event that occurs in 80%, as was the case in the multiple hospitalizations in this patient. The events of fever were associated with neutropenia and on various occasions there was evidence of infectious foci (aural, pulmonary, and gastrointestinal, GI). The events of fever and neutropenia presented by the patient were categorized as high risk because of profound neutropenia lasting >7 days and hemodynamic instability and GI symptoms characterized by vomiting and diarrhea.

Although the clinical criteria for neutropenic colitis are not well established, one study found that diarrhea and associated hypotension were the most common symptoms in patients with this condition. The patient in the present case presented these symptoms coupled with fever and profound neutropenia $<$100/mm$^3$.

Treatment of ALL is carried out in three stages as follows:

- Induction of remission
- Consolidation phase
- Maintenance phase

With this treatment scheme, 80-85% of patients have a prolonged remission and cure, and 20% may present isolated remission to the bone marrow or extramedullary sites. In this case, the patient had a central nervous system relapse during the maintenance phase. For this reason, she required craniospinal radiotherapy and chemotherapy with vincristine, L-asparaginase, and dexamethasone. The erythema in the left ear lobe was attributed to an allergic reaction to vincristine, which was ruled out because this is not an adverse effect described for such an alkaloid.

![Thoraco-abdominal tomography](image-url)
Mixed septic shock refractory to amines conditioned multiple organ failure (MOF).

2.3.1. Cause of death

4) Hepatic dysfunction with alanine aminotransferase.

3) Renal dysfunction with creatinine 1.7 mg/dl.

During the patient's last admission, she presented with a rapidly evolving acute infectious gastroenteritis with severe dehydration, which ended up in a mixed, hypovolemic and acidotic shock to amines who required the administration of stress doses of hydrocortisone.

Diagnosis of septic shock was based on the presence of tachycardia, tachypnea, hypotension, prolonged capillary refill, weak pulses, decompensated metabolic acidosis, hyperlactatemia of 9.7. There was no improvement after administration of two boluses with saline and administration of adrenaline, dobutamine and meropenem. A true neutropenic colitis was documented with serum concentration of adrenaline, dobutamine and meropenem.

Hematologic dysfunction with decrease of the three cell lines, indicating leukopenia, hemoglobin 10.6 g/dl, platelets 83,000/mm^3, prothrombin time 130 sec., total neutrophils 100/mm^3, platelets 83,000/mm^3, prothrombin time 130 sec., total neutrophils 130 sec.

Hematologic evaluation: the differential count revealed a decrease in total neutrophils to 100/mm^3, with a shift to the left with evidence of left shift at 2/6 points, indicating 80% risk of death. Observations for cardiovascular resuscitation included: mixed shock refractory to amines and multiple organ failure (MOF), which is classified as primary and which presented itself in the first 7 days of onset. The diagnosis of organ failure index (OFI) is provided in the medical record.

MOF in this patient is comprised by the following data:

4/6 points, indicating 80% risk of death.

During the patient's last admission, she presented with a rapidly evolving acute infectious gastroenteritis with severe dehydration, which ended up in a mixed, hypovolemic and acidotic shock to amines who required the administration of stress doses of hydrocortisone.

With these data, the organ failure index (OFI) is calculated as follows:

OFI = [4/6] x 100 = 80% risk of death

Probable neutropenic colitis

2.4. Department of Evaluation and Drug Analysis

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2.5. Nephrology (Dr. Ricardo Muñoz Arizpe)

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3) Renal dysfunction with creatinine 1.7 mg/dl.

Although they are expected effects, neutropenic colitis and mucocytosis are adverse reactions associated with chemotherapy and, as such, should be reported to the Department of Evaluation and Drug Analysis.

2.6. Pathology (Dr. María Sánchez Escobar Algeria)

Mention is made in the clinical history of symptoms of acute lymphoblastic leukemia in maintenance phase with central nervous system relapse and extensive hemosiderosis.

Acute lymphoblastic leukemia in maintenance phase with central nervous system relapse and extensive hemosiderosis.

With this history, especially in an immunocompromised child with this history, especially in an immunocompromised child, tests for bacterial and mycobacterial infection should be done to rule out the possibility of bacteremia and mycobacterium infection.

This should be done in any patient with symptoms of sepsis and pneumonia, especially in an immunocompromised child with symptoms of sepsis and pneumonia, especially in an immunocompromised child.

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deposition. It is important to mention the presence of megakaryocytes as it is the first series that disappears in the presence of leukemia. At this time, the bone is recovered. With a 100× objective we can see the presence of histiocytes with erythrocytes in their cytoplasm. This hemophagocytosis is secondary to a neoplastic process, both the neoplastic process as well the treatment and evolution of this patient (Fig. 3).

Postmortem diagnoses of bone marrow were as follows:

- Bone marrow in remission without the presence of blasts with presence of hemosiderosis, hemophagocytosis and of the three hematopoietic series with normal maturation.

3. Final diagnoses

Principal disease: Acute ALL in remission.

There were no significant changes in the outer habitus. The abdominal content was observed to have an important distension of the bowel loops. There were 35 mL of blood found in the left hemithorax and 25 mL in the pericardium, as well as a mediastinal hemorrhage. Histological sections of the mediastinum demonstrated adipose tissue with extensive hemorrhage. Remnants of the thymus demonstrated calcified Hassall corpuscles and lymphoid depletion. Continuing with the mediastinum, the heart had a weight of 100 g vs. 115 g expected. What was notable, from a macroscopic point of view, was the petechial hemorrhage in the pericardium, the atrium and the right ventricles. As observed from its posterior face, hemorrhage was demonstrated in the adventitia of the pulmonary artery and there was a subepicardiac hemorrhage of 3 × 2 cm. Histological sections demonstrated cardiomyocytes with vacuolated cytoplasm, some with mild increase in the size of the nucleus. This is important because the patient had received daunorubicin, which is cardiotoxic. However, there are no histological changes secondary to the administration of this drug. The liver had an expected weight of 1600 g vs. an expected weight of 756 g. Macroscopically, a light brown color was seen; many changes were histologically seen such as important changes in the architecture due to the presence of fibrosis mainly at the central venous level. At the level of the portal spaces and central veins many hemosiderophages were observed (Fig. 4). In the lobule, there is macro- and microvesicular steatosis. These data are important in the lesion due to drugs which, apparently, is what is seen in the liver. The presence of macrovesicular steatosis is secondary to steroids, and the presence of microvesicular steatosis is secondary to the administration of methotrexate and L-asparaginase. Fibrosis, and the damage that we see in the portal spaces, is secondary to the hemosiderin deposit that is so extensive in the patient. There is also intracytoplasmic cholestasis. A Masson stain was done where the presence of fibrotic bridges can be observed, which join the central veins with the portal spaces, data suggestive of an irreversible lesion that most probably would progress to cirrhosis. A greater increase is evident of collagen IV and VI deposits and the important expansion at the level of the portal spaces and central veins. In a Perls stain, specific for demonstrating iron deposits, the presence of hemosiderophages are seen, with distribution in coarse granules in all fields (Fig. 5). This is important because histological grading is done based on this information. This is a grade IV/IV on the Krause scale, with presence of hemosiderin in all fields with coarse granule distribution.

The spleen also had an increased weight of 260 g vs. an expected weight of 73 g. Histologically, congestion of the red pulp was observed, hemosiderin deposition and significant decrease in the lymphoid tissue in the white pulp. In other areas the presence of fibrosis and hemosiderophages that correspond to a passive chronic congestion of the spleen are seen.

Continuing with the mononuclear phagocyte system, the lymph nodes are normal size and what is observed...
Acute lymphoblastic leukemia in maintenance phase with central nervous system relapse and extensive hemosiderosis is the depletion of lymphoid tissue. Follicles were not observed. All these changes are secondary to chemotherapy. There was also an extensive hemosiderosis, with numerous hemosiderophages located in the cortical as well as in the medullary sinuses. With these findings, the concomitant changes are listed below.

- Subepicardial hemorrhage of 3 × 2 cm
- Hepatomegaly (1600 g vs. 756 g)
- Macro- and microvesicular panlobular steatosis compatible with drug damage
- Stage III/IV extensive portal fibrosis
- Hemosiderosis Krause grade IV/IV
- Splenomegaly (260 g vs. 73 g)
- Chronic passive congestion
- Hemosiderosis Krause grade IV/IV in lymph nodes and spleen
- Lymphoid depletion
- Hemophagocytosis in lymph nodes and bone marrow
- Acute thymic involution

In two articles, reference is made to the presence of liver damage secondary to hemosiderin in patients who had been treated with multiple transfusions, mainly for ALL. In a study that included 30 liver biopsies, the most significant damage was fibrosis.

The lungs weighed almost double their normal weight. Macroscopically, there were areas of congestion at the level of the basal lobes; histologically, the architecture was preserved. What called the attention was the presence of some areas of atelectasis and intraalveolar edema (Fig. 6). There were also vegetable fibers in the lumen of the bronchioles; however, there was no tissue reaction found and this suggests that the patient probably had episodes of bronchoaspiration. One must remember that the patient was immunocompromised and so did not present a good inflammatory response. However, some foci of inflammatory infiltrate were observed, both in the alveoli as well as in the bronchi and bronchioles. There was no presence of microorganisms, which were intentionally sought; among them, *Pneumocystis jiroveci*.

The brain was mildly decreased in weight with respect to what was expected (1150 g vs. 1275 g) and presented significant congestion of the subarachnoid vessels as seen by the convexity and by the base. On serial cuts, a discrete dilatation of the ventricular system was observed. Histological sections demonstrated neuronal hypoxia (Fig. 7). Numerous cuts were evaluated to confirm the presence of blasts both in the subarachnoid vessels as well as in the parenchymal vessels. At that time there was no neoplastic activity at the CNS level or in any other site.

The esophagus presented congestion, especially at the level of the superior third, as did the gastric mucosa, which preserved its folds. Histological sections demonstrated wall integrity with preserved mucosa, submucosal congestion and contraction bands at the level of the muscular wall, secondary to shock. The remainder of the gastrointestinal tract showed the following. In the small intestine a mild flattening of the folds was noted. Microscopically the wall was complete, with only adipose infiltration, most probably because the patient was overweight secondary to the administration of steroids. All the cuts demonstrated...
whole mucosa, depletion of lymphoid tissue and submucosal congestion. The different segments of the colon demonstrated complete mucosa. It is notable that there is no macroscopic data of neutropenic colitis. There is no presence of necrosis and this is corroborated histologically because the wall and the mucosa are seen to be completely whole. There were only contraction bands seen in the muscular wall secondary to shock (Fig. 8).

In the pancreas, areas of congestion were observed. One must keep in mind that this patient received L-asparaginase, which can cause pancreatitis; however, this patient did not present any histological changes. Some ducts were seen that presented mild secretion within their lumen, probably secondary to shock and dehydration. The islets of Langerhans were histologically normal as were the acini.

The kidneys were increased in weight (260 g vs. 165 g). The congestion at the level of the renal medulla is notable; however, the cortex-medulla relationship was preserved. Histologically, congestion was found only at the level of the glomerular capillaries and loss of cortical tubule epithelium, secondary to shock. There are no data of leukemic infiltration or of inflammation or microorganisms.

The clinical history reports that the patient presented with multiple episodes of lower urinary tract infections. The bladder had mucosal edema and significant thickening (∼1 cm thickness) of the muscular wall. However, the bladder urethra was permeable. Histologically, hypertrophy of the bladder wall was observed, but there was no fibrosis and there were no data of infectious processes or recent reactions. Only observed in the wall was hypertrophy secondary to multiple infectious processes that the patient presented (Fig. 9). The clinical history also described that the patient had vaginal secretions. Macroscopically, the reproductive system (ovaries, uterus and vagina) was without alterations. At the time of the study, a frotis of the vaginal secretion was obtained and only epithelial cells were observed. There was no presence of fungus, viral inclusions or any other microorganisms. The sections that correspond to the uterus showed the ectocervix with integral stratified nonkeratinized squamous epithelium and slight congestion of stromal vessels. The endometrium also did not show histological changes, and the ovaries demonstrated primary follicles and the stroma without changes.

The adrenal gland showed congestion of the cortex and medulla. There were no other abnormalities. With these findings the following comorbid diagnoses were integrated:

- Bilateral bronchopneumonia
- Bilateral intra-alveolar edema
- Cerebral atrophy (1175 g vs. 1250 g)
- Hypertrophy of the bladder wall
- Anatomic data of shock:
  - Hypoxic ischemic visceral myopathy
  - Acute tubular necrosis
  - Multivisceral congestion

Postmortem cultures were as follows:

- Blood culture: *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus viridans*
- Right lung: *Streptococcus viridans*, *Streptococcus sp.*
- Left lung: *Streptococcus viridans*, *Streptococcus sp.*, *Staphylococcus aureus*
- Small intestine: *Pseudomonas stutzeri*, *Shewanella putrefaciens*
- Large intestine: three morphotypes of *Escherichia coli*, *Citrobacter youngue*, *Citrobacter amalonaticus*
- Perianal: *Escherichia coli*, *Citrobacter youngue*, *Citrobacter amalonaticus*
- CSF, spleen and liver: negative
relapse, the patient did not benefit from the bone marrow transplant. In this case with CNS involvement, treated exclusively with chemotherapy, the possibility of achieving a second remission was almost 95%. Patients with extramedullary relapse after 18 months had an overall 5-year survival of 40%.

4. Expert commentary

There are various factors that affect chemotherapy toxicity. Some have dose limitations, for example, age, body weight, sex and renal and hepatic function. There are various factors that affect the pharmacokinetics of chemotherapy such as age, body weight, sex and renal and hepatic function.

4.1. Oncology (Dr. Miguel Angel Palomo)

Microbial sensitivity to nitrofurantoin. It is necessary to consider the susceptibility of the germ, the action mechanism of the antibiotic and the state of immunocompetency in patients with these characteristics.

4.3. Urology (Dr. Fernando González Ledón)

In lower urinary tract infections, nitrofurantoin is a very stable drug. Despite its wide use, a collection of studies considers that a resistance of <20% for a drug is adequate, so its use is considered to be appropriate.

Microbial sensitivity to nitrofurantoin.

4.5. Hematology (Dr. Mariana Revueltas)

Listeria monocytogenes is a potential cause of listeriosis. It is noteworthy that no infectious or neoplastic activity were found.

Some patients had liver failure. It is very important to consider the number of transfusions and to assess ferritin levels.


