



# High-Dose Vitamin C (PDQ®)

## Overview

- Vitamin C is a nutrient found in food and dietary supplements. It is an antioxidant and also plays a key role in making collagen (see [Question 1](#)).
- High-dose vitamin C may be given by intravenous (IV) infusion (through a vein into the bloodstream) or orally (taken by mouth). When taken by intravenous infusion, vitamin C can reach much higher levels in the blood than when the same amount is taken by mouth (see [Question 1](#)).
- High-dose vitamin C has been studied as a treatment for patients with cancer since the 1970s (see [Question 2](#)).
- Laboratory studies have shown that high doses of vitamin C may slow the growth and spread of prostate, pancreatic, liver, colon, and other types of cancer cells (see [Question 5](#)).
- Some laboratory and animal studies have shown that combining vitamin C with anticancer therapies may be helpful, while other studies have shown that certain forms of vitamin C may make chemotherapy less effective (see [Question 5](#)).
- Animal studies have shown that high-dose vitamin C treatment blocks tumor growth in certain models of pancreatic, liver, prostate, and ovarian cancers, sarcoma, and malignant mesothelioma (see [Question 5](#)).
- Some human studies of high-dose IV vitamin C in patients with cancer have shown improved quality of life, as well as improvements in physical, mental, and emotional functions, symptoms of fatigue, nausea and vomiting, pain, and appetite loss (see [Question 6](#)).
- Intravenous high-dose ascorbic acid has caused very few side effects in clinical trials (see [Question 7](#)).
- While generally approved as a dietary supplement, the U.S. Food and Drug Administration (FDA) has not approved the use of IV high-dose vitamin C as a treatment for cancer or any other medical condition (see [Question 9](#)).

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## Questions and Answers About High-Dose Vitamin C

### 1. What is high-dose vitamin C?

Vitamin C (also called L-ascorbic acid or ascorbate) is a nutrient that humans must get from food or dietary supplements since it cannot be made in the body. Vitamin C is an antioxidant and helps prevent oxidative stress. It also works with enzymes to play a key role in making collagen.

When taken by intravenous (IV) infusion, vitamin C can reach much higher levels in the blood than when it is taken by mouth. Studies suggest that these higher levels of vitamin C may cause the death of cancer cells in the laboratory.

A severe deficiency (lack) of vitamin C in the diet causes scurvy, a disease with symptoms of extreme weakness, lethargy, easy bruising, and bleeding. The lack of vitamin C in patients with scurvy makes collagen thinner in texture; when vitamin C is given, collagen becomes thicker again.

### 2. What is the history and use of high-dose vitamin C as a complementary and alternative treatment for cancer?

High-dose vitamin C has been studied as a treatment for patients with cancer since the 1970s. A Scottish surgeon named Ewan Cameron worked with Nobel Prize-winning chemist Linus Pauling to study the possible benefits of vitamin C therapy in clinical trials of cancer patients in the late 1970s and early 1980's.

Surveys of healthcare practitioners at United States CAM conferences in recent years have shown that high-dose IV vitamin C is frequently given to patients as a treatment for infections, fatigue, and cancers, including breast cancer.

### 3. What is the theory behind the claim that high-dose vitamin C is useful in treating cancer?

More than fifty years ago, a study suggested that cancer was a disease of changes in connective tissue caused by a lack of vitamin C. In the 1970's, it was proposed that high-dose ascorbic acid could help build resistance to disease or infection and possibly treat cancer.

Later studies showed that the levels of vitamin C that collect in the bloodstream depend on how it is taken.

#### 4. How is high-dose vitamin C administered?

Vitamin C may be given by intravenous (IV) infusion or taken by mouth, although much higher blood levels are reached when given intravenously.

#### 5. Have any preclinical (laboratory or animal) studies been conducted using high-dose vitamin C?

Laboratory studies and animal studies have been done to find out if high-dose vitamin C may be useful in preventing or treating cancer.

##### Laboratory studies

Many laboratory studies have been done to find out how high-dose vitamin C may cause the death of cancer cells. The anticancer effect of vitamin C in different types of cancer cells involves a chemical reaction that makes hydrogen peroxide, which may kill cancer cells.

Laboratory studies have shown the following:

- Treatment with high-dose vitamin C slowed the growth and spread of prostate, pancreatic, liver, colon, malignant mesothelioma, neuroblastoma, and other types of cancer cells.
- Combining high-dose vitamin C with certain types of chemotherapy may be more effective than chemotherapy alone:
  - Ascorbic acid with arsenic trioxide may be more effective in ovarian cancer cells.
  - Ascorbic acid with gemcitabine may be more effective in pancreatic cancer cells.
  - Ascorbic acid with gemcitabine and epigallocatechin-3-gallate (EGCG) may be more effective in malignant mesothelioma cells.
- Another laboratory study suggested that combining high-dose vitamin C with radiation therapy killed more glioblastoma multiforme cells than radiation therapy alone.

However, not all laboratory studies combining vitamin C with anticancer therapies have shown benefit. Combining dehydroascorbic acid, a particular form of vitamin C, with chemotherapy made it less effective in killing some kinds of cancer cells.

##### Animal studies

Studies of high-dose vitamin C have been done in animal models (animals given a

disease either the same as or like a disease in humans).

Some of the studies showed the vitamin C helped kill more cancer cells:

- High-dose vitamin C blocked tumor growth in animal models of pancreatic, liver, prostate, sarcoma, and ovarian cancers and malignant mesothelioma.
- High-dose vitamin C combined with chemotherapy in a mouse model of pancreatic cancer showed that the combination treatment shrank tumors more than chemotherapy treatment alone.
- Another study showed that vitamin C made a type of light therapy more effective when used to treat mice injected with breast cancer cells.
- A study in a mouse model of ovarian cancer showed that combining intravenous high-dose vitamin C with the anticancer drugs carboplatin and paclitaxel made them more effective in treating ovarian cancer.

However, other animal studies have shown that vitamin C interferes with the anticancer action of certain drugs, including the following:

- Mouse models of human lymphoma and multiple myeloma treated with combinations of vitamin C and chemotherapy or the drug bortezomib had more tumor growth than mice treated with bortezomib alone.

6. Have any clinical trials (research studies with people) of high-dose intravenous (IV) vitamin C been conducted?

Several studies of high-dose vitamin C in patients with cancer have been done in recent years, including the following:

Studies of vitamin C alone

- Intravenous (IV) vitamin C was studied in patients with breast cancer who were treated with adjuvant chemotherapy and radiation therapy. The study found that patients who received IV vitamin C had better quality of life and fewer side effects than those who did not.
- A study of IV vitamin C and high doses of vitamin C taken by mouth was done in patients with cancer that could not be cured. Vitamin C was shown to be a safe and effective therapy to improve quality of life in these patients, including physical, mental, and emotional functions, symptoms of fatigue, nausea and vomiting, pain, and appetite loss.
- Vitamin C has been shown to be safe when given to healthy volunteers and cancer patients at doses up to 1.5 g/kg, while screening out patients with certain risk factors who should avoid vitamin C. Studies have also shown that Vitamin C levels in the blood are higher when taken by IV than when taken by

mouth, and last for more than 4 hours.

## Studies of vitamin C combined with other drugs

Studies of vitamin C combined with other drugs have shown mixed results:

- In a small study of 14 patients with advanced pancreatic cancer, IV vitamin C was given along with chemotherapy and treatment with a targeted therapy. Patients had very few bad side effects from the vitamin C treatment. The nine patients who completed the treatment had stable disease as shown by imaging studies.
- In another small study of 9 patients with advanced pancreatic cancer, patients were given chemotherapy in treatment cycles of once per week for 3 weeks along with IV vitamin C twice per week for 4 weeks. These patients had disease that did not progress for a period of months. The combined treatment was well tolerated and no serious side effects were reported.
- In a 2014 study of 27 patients with advanced ovarian cancer, treatment with chemotherapy alone was compared to chemotherapy along with IV vitamin C. Patients who received IV vitamin C along with chemotherapy had fewer serious side effects from the chemotherapy.
- Patients with acute myeloid leukemia, refractory metastatic colorectal cancer, or metastatic melanoma treated with IV vitamin C combined with other drugs had serious side effects and the disease got worse.

More studies of combining high-dose IV vitamin C with other drugs are in progress.

### 7. Have any side effects or risks been reported from high-dose vitamin C?

Intravenous high-dose ascorbic acid has caused very few side effects in clinical trials. However, high-dose vitamin C may be harmful in patients with certain risk factors.

- In patients with a history of kidney disorders, kidney failure has been reported after ascorbic acid treatment. Patients with a tendency to develop kidney stones should not be treated with high-dose vitamin C.
- Case reports have shown that patients with an inherited disorder called G-6-PD deficiency should not be given high doses of vitamin C, due to the risk of hemolysis (a condition in which red blood cells are destroyed).
- Since vitamin C may make iron more easily absorbed and used by the body, high doses of the vitamin are not recommended for patients with hemochromatosis (a condition in which the body takes up and stores more iron than it needs).

### 8. Have any drug interactions been reported from combining high-dose vitamin C

with anticancer drugs?

A drug interaction is a change in the way a drug acts in the body when taken with certain other drugs. High-dose vitamin C, when combined with some anticancer drugs, may cause them to be less effective. So far, these effects have been seen only in some laboratory and animal studies. No clinical trials have been done to further research these drug interactions in humans.

- Combining vitamin C with an anticancer drug called bortezomib has been studied in cell cultures and in animal models. Bortezomib is a targeted therapy that blocks several molecular pathways in a cell, causing cancer cells to die. Several studies showed that vitamin C given by mouth made bortezomib less effective, including in multiple myeloma cells. A study in mice transplanted with human prostate cancer cells, however, did not show that giving the mice different doses of vitamin C by mouth made bortezomib therapy less effective.
- An oxidized form of vitamin C called dehydroascorbic acid has been studied in cell cultures and in animals with tumors. Several studies have found that high doses of dehydroascorbic acid can interfere with the anticancer effects of several chemotherapy drugs. Dehydroascorbic acid is found in only small amounts in dietary supplements and in fresh foods.

See [Question 5](#) and [Question 6](#) for more information on combining vitamin C with anticancer drugs.

9. Is high-dose vitamin C approved by the U.S. Food and Drug Administration for use as a cancer treatment in the United States?

The U.S. Food and Drug Administration (FDA) has not approved the use of high-dose vitamin C as a treatment for cancer or any other medical condition.

Because dietary supplements are regulated as foods, not as drugs, FDA approval is not required unless specific claims about disease prevention or treatment are made.

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