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Bioavailability of Vitamin C: Taking Early Measurements Reveals Oral Intake of 4000 mg Ascorbic Acid Enters the Blood Equivalent to Intravenous Infusion.

Oral Blood Levels Higher Can be Higher than Intravenous Infusion in the Early Minutes

INTRODUCTION

Repeatable and inexpensive experiments have cast doubt on the hypothesis that only 200 mg of vitamin C taken orally can be absorbed. We measured vitamin C blood levels every minute for the first 40 minutes. By contrast to the prevailing paradigm, our results suggest that up to 4,000 mg of ascorbic acid taken by mouth can produce the same blood concentration as an intravenous infusion. Previous studies did not sample blood levels during the first 30 minutes after oral intake.

METHODS

In 2012, we observed that the Abbott Laboratories FreeStyle® Lite glucose meter was apparently sensitive to vitamin C in the blood. This was based on direct observations and reports from members of the Vitamin C Foundation. These observations suggested that there may be a practical and inexpensive way of estimating vitamin C levels in the body.

The glucose and ascorbate molecules are similar, hence the sensitivity to ascorbate in certain meters. Not every brand or model of glucose meter is sensitive to ascorbate. We tested several that did not measure ascorbate. Researchers have documented the ability of specific glucose meters to measure high levels of ascorbate during and after Intravenous Vitamin C (IV/C).[1] It is possible that the FDA considers glucose meter that react to vitamin C flawed. For this reason, manufacturers may be forced to upgrade their meters, rendering future versions of the Abbott and other meters unusable for vitamin C measurements. Ideally, a low-cost finger-prick ascorbate (vitamin C) meter will be made available that makes accurate measurements.

We calibrated the Abbott FreeStyle® Lite glucose meters against accurately measured solutions of ascorbic acid equivalent to concentrations in the blood.[2] The ability of the meter to measure ascorbate *in vitro* proportional to concentration was verified. The exact concentrations measured *in vivo* are not important to the findings, as they are reported in terms of glucose. The experiments compared relative blood concentrations between different

forms of administration, both oral and intravenous, and different forms of vitamin C.

Our preliminary approach to checking the validity of the finger-stick "glucose" measurements, after testing ascorbate in solutions, involved evaluation and comparison of blood levels after different forms of vitamin C were administered orally and intravenously. For example, we found that vitamin C in the form of ascorbic acid taken by mouth raised blood levels more than the same amount of oral sodium ascorbate.

The subject in these three experiments was a 61 year-old male Type I diabetic. Data was collected using 3 Abbott FreeStyle® Lite glucose meters and all three readings or their averages are plotted. The Abbott units were purchased off-the shelf, and they all responded proportionately to increases in ascorbate concentrations in test solutions, and then during measurements taken while the subject was undergoing intravenous infusions of vitamin C.

The first baseline experiment measured "glucose" levels during an IV/C which presumably pushed 100% of the vitamin into the blood stream. For the IV/C, ascorbate was mixed with sterile water and/or saline, i.e., there was no dextrose or any sugar used in the IV bag during these measurements.

RESULTS

Experiment 1 - Baseline: 10 gram IV/C in fasting subject

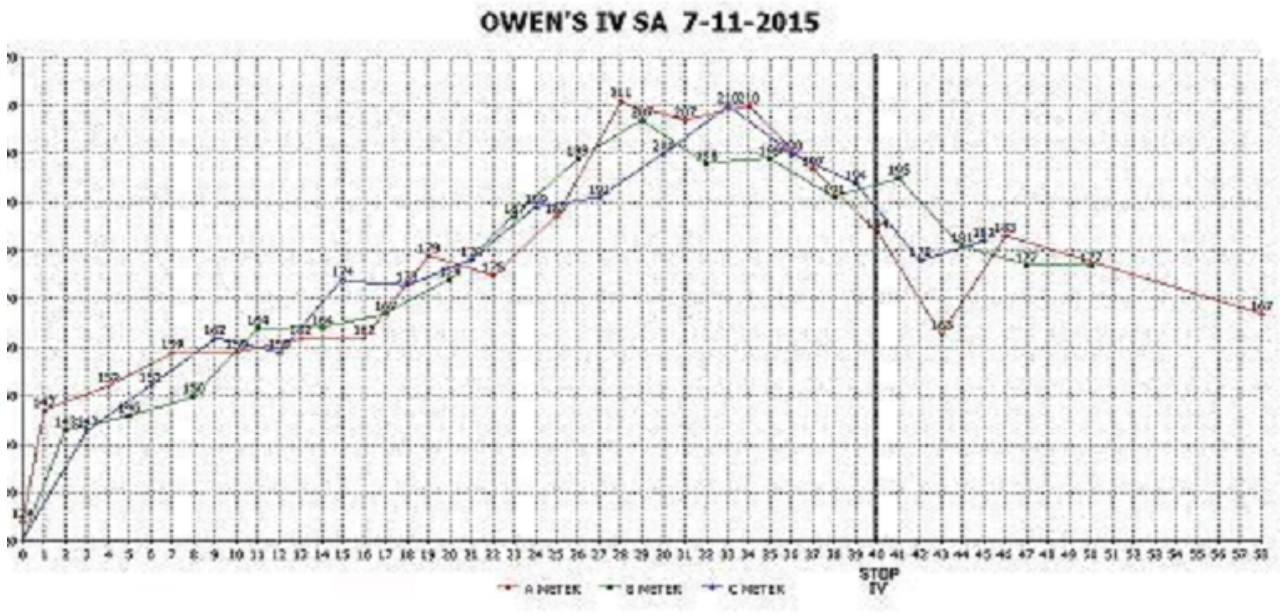

Fig 1. Minute by minute measurement during 10 grams of vitamin C IV. Plot of all 3 glucose meters.

Figure 1 shows the results of 10 grams of ascorbate (11.3 grams of sodium ascorbate) was introduced by vein. The vitamin C was introduced at the rate of 250 mg/minute and thus the duration of the IV was 40 minutes. All three Abbott meters were rotated and reported the same changes in the blood.

The first chart shows the rising levels of vitamin C measured in the blood and the decline towards the end of the IV session. The IV bag emptied at minute 34, and was stopped at minute 40 after the line drained. The increase in concentration from the IV is also consistent with our *in vitro* measurements. The subject had been fasting and the only variable was the introduction of vitamin C by vein. The decline at the end of the IV illustrates the short 30-minute half life of the vitamin. To a first approximation, we take the fasting subject's glucose levels to be constant over this period.

Experiment 2 – Oral Ascorbic Acid at the Same Rate as IV

Figure 2 compares the response from oral ascorbic acid versus our baseline IV administration. The subject was administered vitamin C as the same rate as the infusion, i.e., 250 mg of ascorbic acid by mouth every minute for 40 minutes.

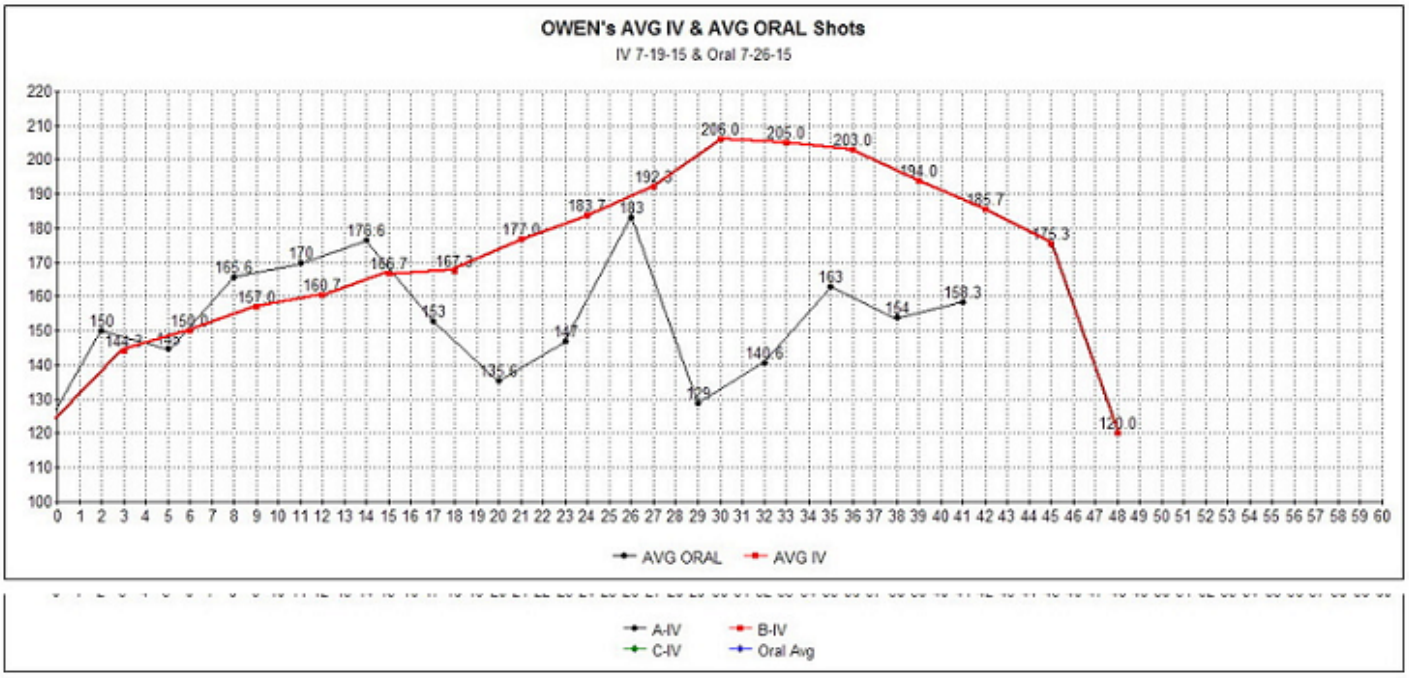

Fig 2. Oral versus IV at the same rate. mg/dl versus time in minutes. IV measurements in red, and the oral intake is black. This plot averages the 3 glucose meters.

The important finding was that during the first 16 minutes, the oral (black line) and IV (red line) blood concentration curves were similar. There was little difference in bio-availability of oral ascorbic acid and IV for the first 4,000 mg at the rate of 250 mg/minute. After this period, the oral blood levels declined, perhaps due to some inherent absorption limit in the GI tract caused by oral intake.

Experiment 3 – 10 grams Ascorbic Acid All At Once compared to IV

In Figure 3, we measured the blood concentrations in the same individual after a single oral dose of 10 grams of ascorbic acid. In the next graph, blood levels spiked early. The maximum levels varied slightly from minute 3 to minute 7. The initial peak had declined back by the 15th minute. During the first 12 minutes, blood concentrations of vitamin C were substantially higher than the levels produced by the intravenous infusion.

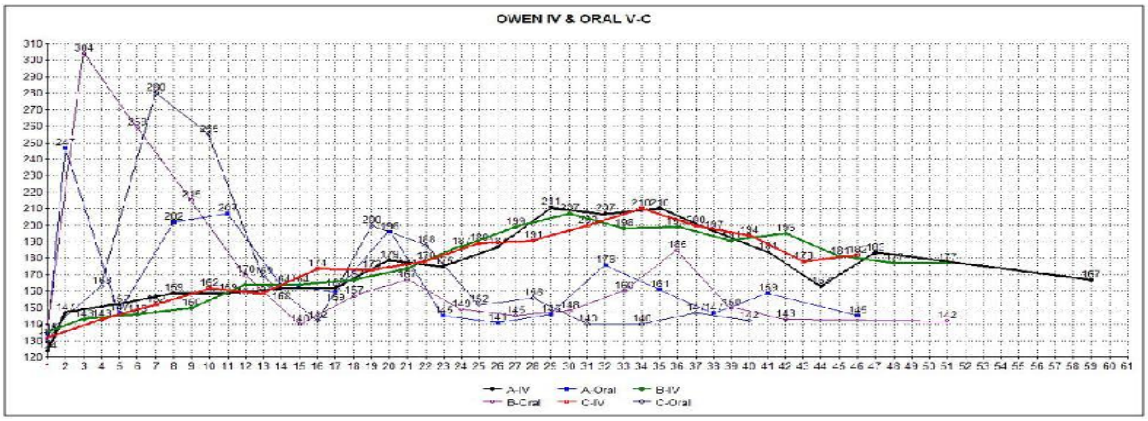

Fig. 3. Time series following a single oral dose versus IV – mg/dl versus time in minutes. All three meters are plotted.

This unexpected finding provides provisional data from direct measurement that oral ascorbic acid can produce transient high blood levels of vitamin C in one subject. These transient high levels do not last long and would be missed by any experiment waiting more than 30 minutes to take the first blood measurement. Rapid minute-by-minute measurements must be taken with a finger-prick meter to observe these high values.

DISCUSSION.

The new vitamin C absorption findings reported here are now possible because some glucose

meters are sensitive to and can be used to report ascorbate levels in the blood. These sensitivity does not normally affect glucose readings because normal ascorbate levels are 1% of the normal glucose concentrations. To our knowledge, these minute by minute measurements are the first to be published, partially because of the difficulty in collecting, and then storing blood for so many measurement in a laboratory.

In this preliminary report, we show that during a slow intravenous infusion of 10 grams of vitamin C, three separate meters report a steady increase in "glucose" consistent with the increased concentration of vitamin C in the blood. (See Figure 1.) When the IV slowed down, after the IV bag emptied, the three meters showed the decrease in blood levels consistent with a short 30 minutes half-life. Drs. Steve Hickey and Hiliary Roberts first reported the short 30-minute half-life of vitamin C. Their ascorbate pharmakinetic findings, based on published data from the US National Institutes of Health(NIH), led them to their *Dynamic Flow* theory of ascorbate.[3] [4]

After our IV/C measurements, the 100% bio-availability baseline, the next experiment, conducted on a different day, introduced the exact same amount of vitamin C as ascorbic acid orally, at the same rate, 250 mg every minute. The subject's initial fasting glucose reading was about the same. The minute-by-minute readings in the same subject dovetailed the IV measurements for the first 4000 mg, leading to the reasonable preliminary conclusion that the same amount of vitamin C entered the blood stream. This is a surprising finding because prior research had reported that only about 250 mg can be absorbed before tissue saturation. However, by the time vitamin C was measured in these earlier experiments, peak levels may have already declined.

In the third experiment, (See Figure 3), we consumed the entire 10 grams of vitamin C as acorbic acid all at one time. These measurements were compared it to the slow intravenous infusion. The surprising finding is that in the first few minutes, the oral intake of 10 grams ascorbic acid created higher blood levels than the IV/C.

We have conducted several other experiments using the Abbott meters that will be discussed in follow-ups to this preliminary article. For example we have found that while ascorbic acid can be rapidly absorbed in to the blood stream, sodium ascorbate raises blood levels more slowly, more like a sustained time release.

CONCLUSION

Vitamin C blood levels must be measured repeatedly within 30 to 40 minutes to obtain an accurate reading of how much vitamin C enters the blood stream. These findings support the late Dr. Robert Cathcart, III, M.D.'s discovery that people who are sick and under stress can tolerate very high oral intakes of vitamin C.[5] The Cathcart bowel tolerance amounts,

sometimes as high as 200 grams daily, are difficult to reconcile with the current paradigm if tissues saturate at 250 mg. We may also have solved another mystery. Dr. Cathcart also reported that he could only obtain the free radical squelching "ascorbate effect" orally with ascorbic acid, not mineral ascorbates. The rapid early absorption and utilization of ascorbic acid presented here, previously unknown, may be the explanation.

ACKNOWLEDGEMENTS

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Dr. John Wench MD did the charts [Y/N]
Dr. Thomas Hesselink MD measured the ascobate and oversaw the IV [Y/N]
Feedback from members of the Vitamin C Foundation forum

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[1] A Convenient Method for Measuring Blood Ascorbate Concentrations in Patients Receiving High-Dose Intravenous Ascorbate, *Yan Ma*, PhD,[1,2] *Garrett G Sullivan*, MD,[2,3,4] *Elizabeth Schrick*, RN,[2] *In-Young Choi*, PhD,[5,6,7] *Zhuoya He*, PhD,[8] *JoAnn Lierman*, RN, PhD,[5] *Phil Lee*, PhD,[5,7] *Jeanne A Drisko*, MD, CNS, FACN,[2,*] and *Qi Chen*, PhD[1,2,*], J Am Coll Nutr. 2013 Jun; 32(3): 187–193. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3725640/

[2] All measurements and data values are recorded at the Vitamin C Foundation forum under the topic "Bioavailability of Vitamin C."

[3] Hickey Ascorbate/Science
[4] Hickey Ridiculous
[5] Cathcart Bowel Tolerance paper