Original Article

Effect of Iodinated Contrast Media on Serum Electrolyte Concentrations in Patients Undergoing Routine Contrast Computed Tomography Scan Procedure

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Abstract

Background and Objectives: Being hypertonic solutions, iodinated contrast media such as iohexol can cause a shift of fluids and electrolytes between different compartments of the body, but there is an ongoing discrepancy in data and current studies as to the effect of iodinated contrast media on serum electrolytes. Hence, this hospital-based prospective clinical observational study was carried out with objectives of evaluating the changes in serum electrolyte concentrations with intravenous iodinated contrast media administration in adult population and to correlate the changes in electrolyte concentrations, if any, with the demographic profile of the patients. **Materials and Methods:** We analyzed 103 numbers of adult patient samples over a period of 2 months by collecting blood both before administration of contrast and after 24 h of the contrast-enhanced computed tomography scan procedure. Serum concentrations of sodium, potassium, chloride, and ionized calcium were measured using Eschweiler Combiline analyzer based on ion-selective electrode principle. **Results:** The mean age of the study population in our study was 40.11 ± 20.51 years. We found that changes in serum sodium and chloride concentration after administration of contrast media are significant (sodium: 136.29 ± 3.53 vs. 132.49 ± 6.36 mmol/L and chloride: 100.03 ± 0.70 vs. 97.53 ± 0.70 mmol/L). Sodium concentration shows more decrease in females compared to males after administration of iodine contrast. The most probable reason for this decrease in serum electrolytes was secondary changes to hemodilution due to high osmolality of the contrast. **Conclusions:** Attending physicians must be alert for such possibilities of changes in electrolytes after contrast administration and be prepared to treat any adversity if one occurs.

Keywords: *Contrast media, computed tomography scan, electrolytes, hyponatremia, iodine*

Introduction

Diagnostic tests such as computed tomography (CT), magnetic resonance imaging, and angiograms are routinely used in most hospitals because they provide valuable information about many diseases and injuries and help in both diagnosis and treatment. In many of these cases, a group of medical drugs in the form of a radiographic contrast media are used to improve the visibility of organs and structures.[1-3] Like all pharmaceuticals, these agents are also not completely devoid of risks, and adverse reactions can occur from transient minor reactions to life-threatening severe reactions.[4-7]

Being hypertonic solutions, iodinated contrast media such as iohexol can cause a shift of fluids and electrolytes between different compartments of the body.[3] A study by Hayakawa *et al*. on Japanese white rabbits on the effect of intravenous contrast media on electrolytes found that there were no significant alterations in serum electrolytes.[8] However, a study by Dennhardt *et al*. on the pediatric population found that the use of hyperosmolar contrast media during cardiac catheterization in pediatric population resulted in significant changes in electrolytes, osmolality, and acid-base balance.[9] Another case was reported where an 84-year-old woman developed acute severe symptomatic hyponatremia following coronary angiography with behavioral and neurological manifestations.[10] A study by Sirken *et al*. on five patients with advanced kidney disease who underwent diagnostic and/or therapeutic cardiac catheterization developed hypertonic hyponatremia and hyperkalemia.[11]

How to cite this article: Sankaran S, Saharia GK, Naik S, Mangaraj M. Effect of iodinated contrast media on serum electrolyte concentrations in patients undergoing routine contrast computed tomography scan procedure. Int J App Basic Med Res 2019;9:217-20.

Received: 19 February, 2019.
Revision: 27 March, 2019.
Accepted: 29 July, 2019.
Published: 11 October, 2019.

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Access this article online

Website: www.ijabmr.org

DOI: 10.4103/ijabmr.IJABMR_69_19

Quick Response Code:

From the above discussion, it is quite clear that there is an ongoing discrepancy in data and current studies as to the effect of iodinated contrast media on serum electrolytes. Here, we aim to measure the serum electrolytes both before and after the contrast CT scan procedure and understand if any significant change occurs, thus clearing the confusion and shedding some light on this matter. Considering the low number of available studies and lack of literature from this part of the country, our study hopes to obtain a deeper understanding so that prompt diagnosis and treatment can be done in case of any adversity. We hypothesize that the use of the so-called nonionic low-osmolar contrast media (which still have considerably higher osmolality than plasma) may produce significant changes in the electrolyte concentrations in patients undergoing contrast-enhanced CT (CECT) procedure. Hence, the objectives of our study are to evaluate the changes in serum electrolyte concentrations with intravenous iodinated contrast media administration in adult population and to correlate the changes in electrolyte concentrations, if any, with the demographic profile of the patients.

Materials and Methods

Patient recruitment

The present study was a hospital-based prospective clinical observational study in all patients above the age of 18 years who underwent a CECT scan. We analyzed 103 numbers of patient serum samples over a period of 2 months from August 1, 2017, to September 30, 2017, in the Department of Biochemistry, and CECT scans were done in the Department of Radiodiagnosis, AIIMS, Bhubaneswar, Odisha, India.

Experimental design and sample collection

Blood sample collection was started after obtaining clearance from the Institutional Ethical Committee of AIIMS, Bhubaneswar, Odisha, India, and informed consent was taken from all participants. Patients having serum creatinine level more than 1.2 mg/dL, patients with known hypersensitivity to iodine and/or iohexol, patients taking drugs such as diuretics, monoamine oxidase (MAO) inhibitors, antipsychotic agents, and metformin were excluded from the study. Blood samples of all the patients were collected both before administration of contrast and after 24 h of the CECT scan procedure.

Contrast media administration

Iodinated contrast media was given intravenously in a dose of 1.0 ml/kg of body weight routinely for different parts of the body. Serum concentrations of sodium, potassium, chloride, and ionized calcium were measured using Eschweiler Combiline analyzer based on ion-selective electrodes principle where daily two levels of aqueous quality control material from Eschweiler GmbH and Co., Germany, were run in the morning.

Statistical analysis

Chi-square test and Student's *t*-test were used for tests of statistical significance wherever appropriate. $P < 0.05$ was considered statistically significant. Statistical analysis was done using R version 3 (Vienna, Austria). "R" is a programming language and free software environment for statistical computing and graphics supported by the R Foundation for Statistical Computing. The data for serum concentration of sodium, potassium, and ionized calcium were normally distributed, but data distribution for serum chloride was not normal.

Results

The mean age of the study population in our study was 40.11 ± 20.51 years. Out of 103 study participants, 54% are male [Figure 1]. Our study participants aged from 18 to 85 years, and the age distribution of study population is shown in Figure 2. From Table 1, it is evident that changes in serum sodium and chloride concentration after administration of contrast media are significant. No significant variations are observed in different age groups after administration of contrast with respect to the blood parameters under consideration. When gender-wise variation is analyzed, then it was found that serum sodium concentration shows more decrease in females compared to males after administration of iodine contrast and the difference is 1.99 mmol/L (confidence interval 0.25–3.7, $P = 0.03$). No such significant gender difference is observed for other parameters.

Discussion

In the given period of 2 months, a total of 103 patient samples were taken both before and after CECT scan procedure and analyzed for change in serum electrolytes along with change in both serum urea and creatinine. About 45% of our study population was female and 55% male. Considering that no large-scale study has been undertaken regarding change in serum electrolytes with contrast administration, it is not possible to do a comparative demographic profiling with previous studies.

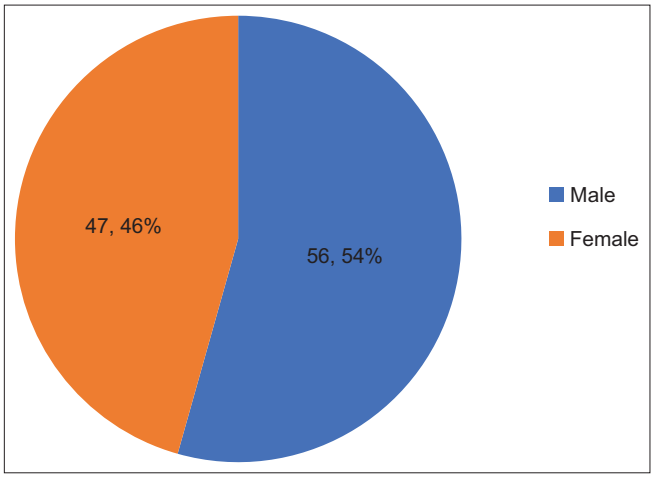

Figure 1: Gender distribution of study population

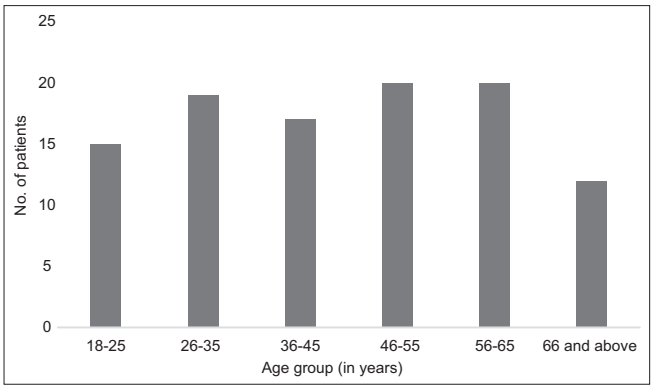

Figure 2: Age distribution of study population

Table 1: Mean serum concentration of different parameters before and after contrast administration

Parameter	Mean±SD		*P*
	Before	After	
Urea (mg/dl)	18.17±3.53	21.36±0.70	<0.001
Creatinine (mg/dl)	0.79±0.70	0.90±0.07	<0.001
Sodium (mmol/L)	136.29±3.53	132.49±6.36	<0.001
Potassium (mmol/L)	4.03±0.01	3.99±0.04	0.374
Chloride (mmol/L)	100.03±0.70	97.53±0.70	0.0006
Ionized calcium (mmol/L)	0.96±0.01	0.95±0.01	0.298

Changes in serum sodium and chloride concentration after administration of contrast media are significant. SD: Standard deviation

The mean sodium concentration before and after contrast administration was 136.29 and 132.49 mmol/L, respectively. The decreased sodium concentration was found to be statistically significant on applying Student's *t*-test. Similar was the result with serum chloride concentration. Thus, there was reduced serum sodium and chloride concentration after 24 h of contrast administration though none of our patients showed overt clinical symptoms. The study by Brunet *et al*. on 20 adult patients showed that there was a statistically significant decrease in serum sodium, potassium, calcium, chloride, phosphate, albumin, and osmolality after 5 min of contrast introduction, and except for potassium which returned to the baseline, the decrease in other electrolytes persisted even after 30 min of contrast administration.[3] It was hypothesized that the most probable reason for this decrease in serum electrolytes was secondary changes to hemodilution due to high osmolality of the contrast. Furthermore, osmotic diuresis secondary to contrast administration may have contributed to hyponatremia. The retrospective study by Sirken *et al*. on patients with contrast-induced symptomatic hyponatremia in patients with advanced kidney disease said that the cause of hyponatremia and any electrolyte imbalance may depend on the dose of contrast administered (translocational) or fluids administered (dilutional) and was not related to the impaired urinary diluting capacity.[11]

Our study did not show significant alterations in potassium concentration. A study by Hayakawa *et al*. revealed that the level of potassium remained almost unchanged most probably because the concentration of potassium is higher intracellularly and potassium can be released from red blood cells and vascular endothelial cells.[8] Our study also did not show significant changes in the ionized calcium concentration although there was a decrease in the serum ionized calcium concentration after the administration of contrast. This is contradictory to the available literature. Hayakawa *et al*. reported a negative interference by ionic contrast media in the determination of ionized calcium, and the effect was attributed to the unbound anions of the contrast and their potentiation of calcium binding.[12] On the other hand in 2017, Otnes *et al*. found a positive interference by the contrast agents.[13] However, both the studies were *in vitro* experiments, and hence, it is difficult to distinguish actual *in vivo* effects from *in vitro* effects.[12,13] Although none of our patients showed overt clinical symptoms, there have been different case scenarios of metabolic disturbances that could not be explained by any other cause other than contrast administration.[9,11] Furthermore, none of the patients involved in the study showed other adverse reactions to the contrast administered such as hypersensitivity reactions, thyroid manifestations, or nephropathic changes.

Conclusions

From this hospital-based observational study, it is quite clear that contrast administration has some impact on serum electrolytes and can cause metabolic disturbances. Although in most case scenarios they do not cause any overt symptoms, there is always a possibility of it manifesting especially if there was a preexisting electrolyte abnormality which got compounded on use of contrast. Attending physicians must be alert for such possibilities and be prepared to treat any adversity if one occurs. Continuous monitoring of serum electrolytes post-CECT scan procedure is very much essential with more precaution to be taken in case of female gender. Furthermore, more studies are essential in this field in different hospital settings and more research and thought must be put into the physiological basis behind the shift of fluid and electrolytes and how it interacts with various administered contrast media.

Acknowledgment

The authors would like to acknowledge Dr. Anand Srinivasan (MD, DM), Assistant Professor of Pharmacology, AIIMS, Bhubaneswar, Odisha, India, for the statistical analysis using R software. The authors are also thankful to the Short-Term Studentship (STS) Program of ICMR for the grant and for providing us with an opportunity to familiarize our undergraduate medical students with research methodology and techniques.

Financial support and sponsorship

This study was financially supported by the INR 10,000 under Short Term Studentship Program of Indian Council

of Medical Research (ICMR) to Ms. Sindhu Sankaran with reference ID 2017-03674.

Conflicts of interest

There are no conflicts of interest.

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