EVALUATION OF DIFFERENT CONTRAST MEDIUM INJECTION TECHNIQUES IN THE ANGIO-CT STUDY OF THE LOWER LIMBS IN PATIENTS WITH OBLITERATING ARTERIOPATHY

Di Basilio Francesco[1], Canitano Stefano[2], Micheli Cinzia[3], Bifarini Roberta[4], Aguzzi Gilberto[5], Camerini Erika[5], Caprioli Gianluca[5], Iacoboni Francesco[5], Castrogiovanni Marco[5], Raimondi Cecilia[5], Bracci Matteo[5]

[1]Radiographer, DEA Group Hospital San Camillo de Lellis of Rieti - Scientific Director, AITRI
[2]Director of UOC Diagnostics for Images, ASL Rieti
[3]Director of UOSHeavy Technologies CT and MRI and Diagnostic Imaging Emergency Department, ASL Rieti
[4]Graduate Student Course Radiographers, University La Sapienza of Rome Headquarters of Rieti
[5]Radiographer, Group Emergency Department Hospital San Camillo de Lellis of Rieti

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ABSTRACT

The need to write this article was born with the aim of optimizing the Angio-CT study protocol of the lower limbs, comparing two Mdc injection techniques: standard and split bolus, performing a parameter check vital collected before and during injection of the Mdc in order to establish the plateau between reaching the peak of enhancement during the smartprep and the start of the scan. Then well defined parameters are assigned for the evaluation of the images obtained with the different techniques.
In the study the inclusion or exclusion parameters of the patient are defined, recruiting 133 cases.
The Split Bolus injection technique is optimal together with an accurate evaluation of the patient's vital parameters. Although appreciating the excellent results, the limits of this study are also described.

INTRODUCTION

The Angio-TC study of the lower limbs represent the Gold-Standard in the planning of revascularization interventions in patients with acute stenosis and/or occlusion of the arterial axes of the lower limbs. A specific study whith the angio-tc can be crucial in chosing the therapeutic strategy between a revascularization with angioplasty or limb amputation, especially for patients suffering from diabetic foot.   Therefore, it is essential that the study record all the vascular axes of the lower limbs from the middle third of the abdominal aorta till the foot arteries.
Regarding èatiens suffering from obstructions spread all over the body, it is extremely important that the circles of compensations are reported.
 It is also important to carry out the exam with a perfect timing between the Mdc injection and the start of the scan, aiming to reduce the venous reflow in the distal area of the lower limbs. The aim is to obtain a rightful exam from the enhancementof the procedure just described, it is necessary to optimize the injections tecnique of the mdc and the acquisition post contrast. With the aim of optimizing the Angio-TC study protocol of the lower limbs at our facility was born our study. The study is conducted by a group of TSRMs working at the DEA of the San Camillo de Lellis Hospital in Rieti, by the TSRM student Roberta Bifarini and coordinated by TSRM Dr. Francesco Di Basilio who took care of the design and execution of the study. For the clinical-medical evaluation part of the study availed itself of the collaboration, especially in the evaluation phase, of 4 medical Specialists Radiologists coordinated by the Director of the UOC Diagnostic Imaging of the Hospital San Camillo de Lellis in Rieti Dr.Stefano Canitano.

AIM

Thanks to this study we were able to compare two different injections tecnique of the mdc in the Angio-TC examination of the lower limbs. The two injections technique compared are as follows:

Standard tecnique	120-140 cc di MdC a 3.5ml/s 30-50 cc di NaCl a 3.5 ml/s
Split bolus tecnique	30 cc di MdC a 4 ml/s 20 cc di MdC a 3.6 ml/s 20 cc di MdC a 3.4 ml/s 40 cc di NaCl a 3.3 ml/s

Tab. 1 - *injection techniques.*

Parameters	Plateau time
Heart rate ≤ 70 bpm and blood pressure ≤ 100 mmHg	15 seconds
Heart rate between 75 e 90 bpm e Blood pressure from 100 e 130 mmHg	12 seconds
Heart rate ≥ 90 btm e blood pressure ≥ 130 mmHg	8 seconds

Tab. 2 - *patient vital signs and plateau times.*

RATING	EVALUA-TION 4	EVALUATION 3	EVALUATION 2	EVALUATION 1
1. DISPLAY OF THE ENTIRE PERIPHERAL ARTERY SYSTEM	GREAT	GOOD	ENOUGH	NOT DIAGNOSTIC
2. DISPLAY OF COMPENSATION CIRCLES	GREAT	GOOD	ENOUGH	NOT DIAGNOSTIC
3. VISUALIZATION OF ARTERIES UNDER POPLITEE	3 ARTERIEs	2 ARTERIEs	1 ARTERIA	0 ARTERIEs
4. PERIPHERAL VENOUS RETURN	NOT PRE-SENT	SLIGHT	IMPORTANT	SUBSTANTIAL

Tab. 3 - *ratings and assessments.*

The split bolus tecnique has been used in a group of patients checking the vital parametersof the patient before the exam and during the execution of the same A further appendix to the study was to use in a group of patients the split bolus injection technique combined with monitoring of the patient's vital parameters before the examination and during the execution in order to establish the plateau between reaching the enhancement peak during the smartprep and the start of the scan using the table described below tab 2.

The study had the aim to compare these tecnique and in order to do so we consider same characteristic in each patient:
- The correct visualization of all the vascular axes, assigning a score of 4 in the patients with a correct evaluation, 3 to those where it was visible a sections smaller than 1.5 cm, 1 for patients where the sections not visible were than 3 cm, 0 to those where was impossible to make a diagnosis of vascular axes.
- If the circles of compensation were correctly showed we assigned, 3 to patients where the circles of compensation weren't fully visible, 2 where they were visible but noy fully just with smal and irrelevant hatching, 1 where they are visible with evident hatching, 0 if they are not visible at all.
- The display of the triforcation of the leg arteries assigning a rate of 3 if the three srteries are visible, 2 if just two out three are visible, 1 if only one artery is visible, 0 if none of the 3 arteries are visible.

- The evaluation of the distal venous blood return, assigning a rate of 2 if there is no venous return, 1 if there is light venous return, 0 if there is an important vonous blood return.

Once we created the rating we compared the results for each mdc injection tecnique and in order to make the mas clear as possible we documented with diagram.

We included in our study:
- Patients suffering from obliterating arteriopathy or diabetic foot
- Patients with claudication
- Patients older than 40 years old
- Patients where a TC scan from the central aorta till the foot arteries were performed
- Patients suffering from stenosis or obstructions proved by the eco color doppler
- Patients with circles of compensations proved by the eco color-doppler

We omitted from the study
- Patients younger than to 40
- Patients with a major cardiomyopathy
- Patients where the claudication wasen't present.
- Patiens without circles of compensation proved by the eco color-doppler

Thank all this criteria we gathered a total of 133 patients (m. 85 ; f 48 ; medium age 68,4 , maximum age 93, minimum age 40) that have had an Angio TC lower limb exam for obliterating arteriopathy in the medical imaging of San Camillo de Lellis di Rieti in the period stanting from Jan. 2016 till June 2018.
The sample is split into 3 groups:

GROUP NAME	N° Patients	M	F	Middle age	Max age	Min. Age
control group	55	34	21	69,5	92	43
split bolus group	55	35	20	68,3	93	41
split bolus + monitoring group	23	17	7	67,8	91	40

Tab. 4 - *patient samples.*

Patient	Rating 1	Rating 2	Rating 3	Rating 4
1				

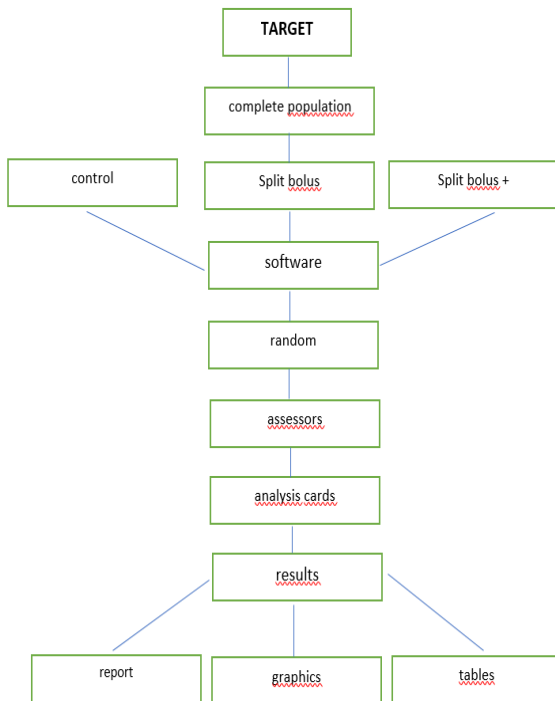Tab. 5 - *evaluation rating table.*

Fig. 1 - *Study process scheme*

For our study we used the observational method assigning to each a progressive number and we create a diagram with progressive number the sex of the patients and the age.

We then produced an evaluation sheet with the four ratings of our firm and the ratings from 1 to 4 as described in the table below tab. 5.

The assessors fullfilled the gap of the diagram with a rate from 1 to 4 with all the criteria described in it.

There were in total 4 assessors that had assigned automatically by a software 33 random patients from three groups, just one assessors received 34 patients.

This sftware sent through e-mail all the file contaning the images to the assessors that they didn't know from which group those files were from, not even the sex and age of the patients.

The only thing that they had was a valutation sheet with only the progression number.

Once they complete the form they send them to the same software ; in this way also those one responsable of analizing the data didn't know who evaluate them.

For each group we found the arithmetic mean of every single rating and we compare the results, in order to understand them better we creat diagram.

For our study we used the following technological elements:

– GE light speed 64 CT scanner included in the DEA diagnostic imaging of San Camillo de Lellis Hospital in RietiScanner
– Philips Ingenuity 128 CT included in the diagnostic imaging of the San Camillo de Lellis Hospital in Rieti
– Medrad double injectors
– GE monitor for monitoring vital signs.
– AVA (advanced vessel analisis) reprocessing software supplied with the PORTAL Philips and AW 45 GE software.
– Excel software for collecting data analysis and processing of results.

RESULTS

GROUP	Rating1				Rating2				Rating3				Rating4			
evaluation	4	3	2	1	4	3	2	1	4	3	2	1	4	3	2	1
control group	19	17	15	4	14	26	11	4	14	17	20	4	4	21	22	8
% average	34.5	30.9	27.3	7	25.5	47.3	20	7	25.5	30.9	36.4	7	7	38.2	40	7
	2.92				2.94				2.74				2.38			
split bolus group	39	13	3	0	29	22	4	0	29	21	4	1	15	32	7	1
% average	70.9	23.6	5.4	0	52.7	40	7	0	52.7	38.1	7	1.8	27.3	58.2	12.7	1.8
% average	3.65				3.45				3.41				3.1			
split bolus group+ monitor	16	5	2	0	16	7	0	0	16	5	2	0	10	10	3	0
% average	69.5	21.7	8.7	0	69.5	30.5	0	0	69.5	21.7	8.7	0	43.8	43.8	12.6	0
	3.6				3.65				3.6				3.3			

	Control	Split bolus	Split bolus + monitor	Split bolus vs control	Split bolus + monitor vs control
Rating 1	2.92	3.65	3.6	20%	18.90%
Rating 2	2.94	3.45	3.65	14.8%	19.50%
Rating 3	2.74	3.41	3.6	19.70%	23.90%
Rating 4	2.38	3.1	3.3	23.3%	27.90%

Tab. 6-7 - *results obtained.*
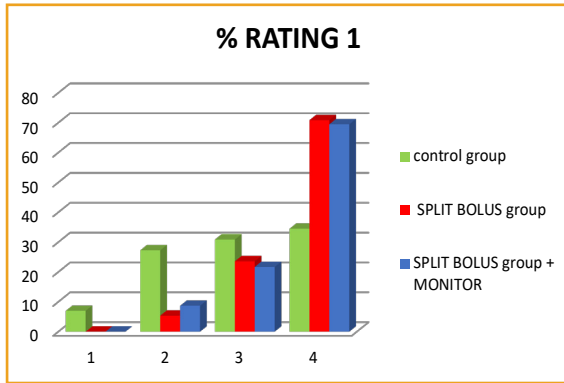
Graph 1 - *% ratings Rating 1*

RATING 1

Visualization of the entire peripheral arterial system a relevant improvement of the performance in the split bolus group compared with the control group.

Indeed the average of the evolution that we optained for this rating it's 2-92 % for the control group and 3.65% for the split bolus group with a 20% improving for the sencond one.

The use of the patient monitoring together with the use of the split bolus tecnique, according to our results, it doesn't increase of the performance since the split bolus group results + monitor (evaluation average 3.6 with an 18.9% increase) are overlap with this optained with group control.
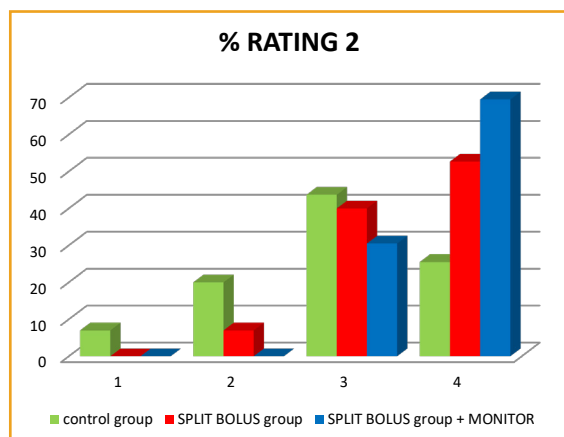
RATING 2

display of compensation circles:

our results show an increase of the performance in the split bolus group compared with control group.

This performance also increase in the split bolus group + monitor.

Indeed the evaluation obtained are 2.94 in the control group, 3.45 in the split bolus group, 3.65 in the split bolus group + monitor.

The improvement of the performance for this rating compared with control group is of 14.8% of the split bolus group and 19.50% for the split bolus group + monitor.

This data show how useful is the monitoring of the patient together with split bolus injection use since this increase of a 4.7% the split bolus group performance compared with control group for this specific rating.
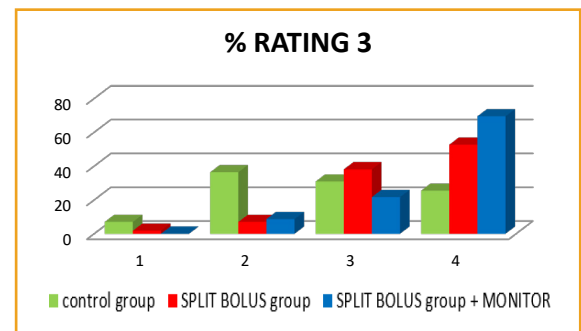

Graph 2 - *% ratings Rating 2*

RATING 3

Display of arteries in the poplited area this result show an increase of the split bolus group performance compared with the control group.

Also for this rating we have an increase in the split bolus group + monitor.

The evaluation everage abtained are 274 in the control group 3.41 in the split bolus group 3.6 in the split bolus group + monitor.

The envelopment improvement of the performance for this rating compared with the control group is of 19.7% for the split bolus group and 23.9% for the split bolus group + monitor.

This data show how useful is the monitoring use of patiens together with the split bolus group injection technique since it increase of a 4.2% Then performance of the split bolus group compared with control group.

Graph 3 - *% ratings Rating 3*
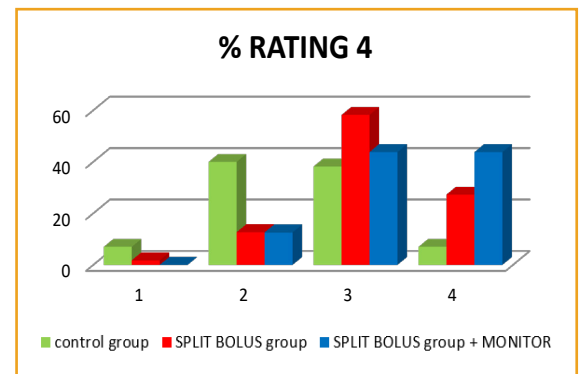
RATING 4

Peripheral venous return

The results show an increase of the performance in the split bolus group compared with control group.

Olso in this rating the performance increase in the split bolus group + monitor.
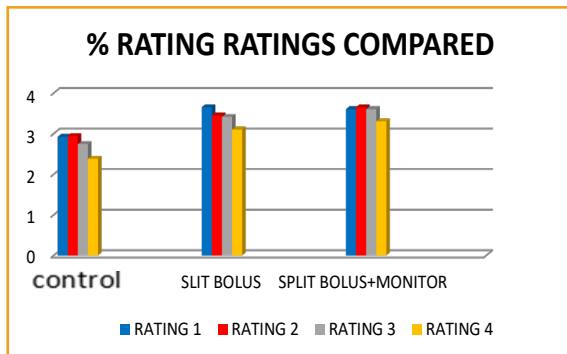
Indeed the evolution average abtained are 2.38 in the control group, 3.1 in the split bolus group, 3.3 in the split bolus group + monitor.

The improvement of this performance for this rating compared with control group is 23.3%, for split bolus group and for the split bolus group + monitor is 27.9%.
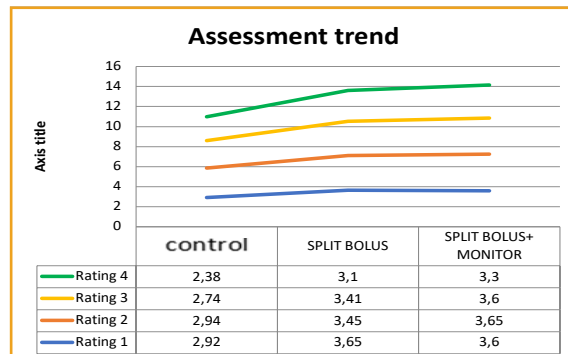
This data show an useful is the monitoring use together with split bolus injection tecnique since it increase of a 4.6% the performance of the split group compared with control group.

Graph 4 - *% ratings Rating 4*

Graph 5 - *% Rating ratings compared*

	control	SPLIT BOLUS	SPLIT BOLUS+ MONITOR
Rating 4	2,38	3,1	3,3
Rating 3	2,74	3,41	3,6
Rating 2	2,94	3,45	3,65
Rating 1	2,92	3,65	3,6

Graph 6 - *trend of evaluations*

■ CONCLUSION

According with results that we carried out, it is significantly indicated the use of the split bolus injection tecnique in the angio-tc lower limb study in patiens soffering from obliterating arteriophaty.

The benefit of this technique are:
- Better display of the vascular intern oxes of the lower limb
- Better displaying and the resolution of the circle of compensation
- Better displaying of the arterie in the poplited area
- Minor venous reflaw and contamination in distal zones
- Minor MDC volume injected

Our study also show haw the addition of the monitoring of the vital function of the patient, in order to the determine the right plateau between the enhancement peak in the aorta and the beginning of the scan, inprove the performance of 3 of the 4 ratings of our study (visualization of compensation circles, visualization of subplastic arteries, peripheral venous return) and therefore the use is indicated where possible.

While being aware that our study has produced clear results it is important to point out the limits such as:
- Study carried out by a single center
- Study carried out by a single team (TSRM DEA San Camillo de Lellis di Rieti)
- No. of patients included in the study
- Limited number of operators (TSRM, Medical Radiologists) involved in the study
- Inhomogeneity in the number of patients among the groups (the Split Bolus + Monitor group is composed of a number of patients equal to less than half the number of the other two groups).

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