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 with the angio-tc can be crucial in choosing 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 patients suffering from obstructions spread all over the body, it is extremely important that the circulation 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 enhancement of the procedure just described, it is necessary to optimize the injections technique 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 technique of the mdc in the Angio-TC examination of the lower limbs. The two injections technique compared are as follows:

<table>
<thead>
<tr>
<th>Injection Technique</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard technique</td>
<td>120-140 cc di Mdc a 3.5 ml/s</td>
</tr>
<tr>
<td></td>
<td>30-50 cc di NaCl a 3.5 ml/s</td>
</tr>
<tr>
<td>Split bolus technique</td>
<td>30 cc di Mdc a 4 ml/s</td>
</tr>
<tr>
<td></td>
<td>20 cc di Mdc a 3.6 ml/s</td>
</tr>
<tr>
<td></td>
<td>20 cc di Mdc a 3.4 ml/s</td>
</tr>
<tr>
<td></td>
<td>40 cc di NaCl a 3.3 ml/s</td>
</tr>
</tbody>
</table>

Tab. 1 - injection techniques.
The split bolus technique has been used in a group of patients checking the vital parameters of 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 techniques and in order to do so we considered some characteristics 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 sections smaller than 1.5 cm, 1 for patients where the sections not visible were than 3 cm, 0 to those where it 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 not fully just with small and irrelevant hatching, 1 where they are visible with evident hatching, 0 if they are not visible at all.

- The display of the triforations of the leg arteries assigning a rate of 3 if the three arteries 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 venous blood return.

Once we created the rating we compared the results for each mdc injection technique and in order to make the map 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 wasn’t present.
- Patients 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 starting from Jan. 2016 till June 2018.

The sample is split into 3 groups:

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

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

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Plateau time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate ≤ 70 bpm and blood pressure ≤ 100 mmHg</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Heart rate between 75 e 90 bpm e Blood pressure from 100 e 130 mmHg</td>
<td>12 seconds</td>
</tr>
<tr>
<td>Heart rate ≥ 90 bpm e blood pressure ≥ 130 mmHg</td>
<td>8 seconds</td>
</tr>
</tbody>
</table>

**Tab. 3 - ratings and assessments.**

<table>
<thead>
<tr>
<th>RATING</th>
<th>EVALUATION 4</th>
<th>EVALUATION 3</th>
<th>EVALUATION 2</th>
<th>EVALUATION 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DISPLAY OF THE ENTIRE PERIPHERAL ARTERY SYSTEM</td>
<td>GREAT</td>
<td>GOOD</td>
<td>ENOUGH</td>
<td>NOT DIAGNOSTIC</td>
</tr>
<tr>
<td>2. DISPLAY OF COMPENSATION CIRCLES</td>
<td>GREAT</td>
<td>GOOD</td>
<td>ENOUGH</td>
<td>NOT DIAGNOSTIC</td>
</tr>
<tr>
<td>3. VISUALIZATION OF ARTERIES UNDER POPLITEE</td>
<td>3 ARTERIEs</td>
<td>2 ARTERIEs</td>
<td>1 ARTERIA</td>
<td>0 ARTERIEs</td>
</tr>
<tr>
<td>4. PERIPHERAL VENOUS RETURN</td>
<td>NOT PRESENT</td>
<td>SLIGHT</td>
<td>IMPORTANT</td>
<td>SUBSTANTIAL</td>
</tr>
</tbody>
</table>

**Tab. 4 - patient samples.**
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. The thisware sent through e-mail all the file containing 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 valluation sheet with only the progression number. Once they complete the form they send them to the same software ; in this way also those one responsible 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 Rieti
- 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 analysis) reprocessing software supplied with the PORTAL Philips and AW 45 GE software.
- Excel software for collecting data analysis and processing of results.

RESULTS

<table>
<thead>
<tr>
<th>GROUP</th>
<th>Rating 1</th>
<th>Rating 2</th>
<th>Rating 3</th>
<th>Rating 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>evaluation</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>control group</td>
<td>19</td>
<td>17</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>% average</td>
<td>34.5</td>
<td>30.9</td>
<td>27.3</td>
<td>7</td>
</tr>
<tr>
<td>split bolus group</td>
<td>39</td>
<td>13</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>% average</td>
<td>70.9</td>
<td>23.6</td>
<td>5.4</td>
<td>0</td>
</tr>
<tr>
<td>split bolus group + monitor</td>
<td>16</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>% average</td>
<td>69.5</td>
<td>21.7</td>
<td>8.7</td>
<td>0</td>
</tr>
</tbody>
</table>

Tab. 6-7 - results obtained.
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 obtained 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 second one. The use of the patient monitoring together with the use of the split bolus technique, 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 obtained 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 use of patients together with the split bolus injection technique since it increase of a 4.2% Then performance of the split bolus group compared with control group.

RATING 3
Display of arteries in the poplitised 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 average obtained 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 patients together with the split bolus group injection technique since it increase of a 4.6% Then performance of the split bolus group compared with control group.
**Peripheral venous return**

Rating 4

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

In the angio-tc lower limb study in patients suffering from obliterating arteriopathy.
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 how 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, improve 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).

**CONCLUSION**

According with results that we carried out, it is significantly indicated the use of the split bolus injection technique in the angio-tc lower limb study in patients suffering from obliterating arteriopathy.

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- Better display of the vascular intern oxes of the lower limb
- Better displaying and the resolution of the circle of compensation
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**REFERENCES**