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X-ray guided tumor percutaneous ablations: The dosimetric impact of different strategies

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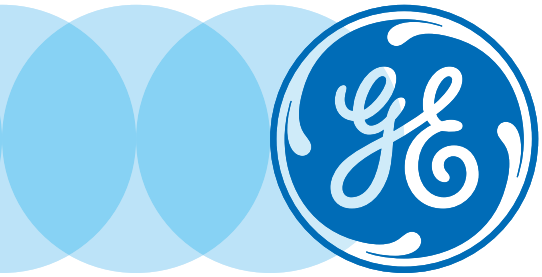

The project at Jean Verdier Hospital investigated the dosimetric implications of different strategies in the performance of X-ray guided tumor percutaneous ablations (TPA).

This paper concentrates on the following areas:

1. Interventional Radiology.
2. Hepatocellular Carcinoma.
3. Tumor Percutaneous Ablations at Jean Verdier Hospital.
4. Optimization of Patient Radiation Protection.

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1. Interventional Radiology (IR)

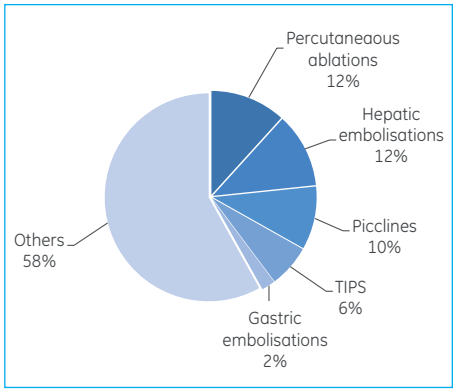
Interventional radiology procedures are less invasive for the patient compared to open surgical techniques. IR is practiced in different fields (vascular, neurology, cardiology,...) and are employed by an increasing number of clinicians.
IR procedures, however, are more complex compared to routine diagnostic radiography exams and can lead to prolonged exposure times. The extended exposure to X-rays can also lead to unwanted stochastic and deterministic effects.

In order to prevent tissue reactions in IR, trigger levels were recommended by the SIR-CIRSE guidelines. They are listed in the following table.

First Notification	Patient Follow Up
Skin dose = 2 Gy	Skin dose = 3 Gy
KAP = 300 Gy.cm^2	KAP = 500 Gy.cm^2
Fluoroscopy time = 30 min	Fluoroscopy time = 60 min

At Jean Verdier Hospital, the Interventional Department Team consists of:
- 4 interventional radiologists
- 4 referent radiology technologists
- 2 medical physicists
- 1 radiology technologists supervisor.

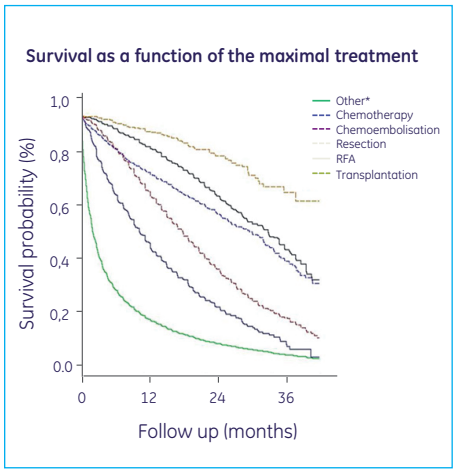
Data and analysis reported in this report were generated using General Electric IGS 540 imager in tandem with GE Healthcare DoseWatch dose monitoring solution.



IR procedures performed at Jean Verdier Hospital

2. What is Hepatocellular Carcinoma?

Hepatocellular carcinoma (HCC) is a primary malignancy of the liver. HCC is the 5th most common malignancy worldwide in men and 7th in women. It is also the 3rd most common cause of cancer mortality. Cirrhosis is present in 80-90 % of HCC patients. Chronic alcoholism remains the first cause of cirrhosis associated with HCC in France.



Goutté N, France, AASLD 2014, Abs. 1572

Tumor incidence varies significantly, depending on geographical location. More than 80% of cases emerge from Eastern Asia and subsaharian region. Incidence is nearly equivalent to mortality. Overall survival is very low, with a median value of 9.4 months.

In France, there were 8723 cases of HCC in 2012. Curative treatments include surgical resection, Liver transplantation, and percutaneous ablations. Chemo embolization and targeted therapies are considered palliative treatments.

3. How Do We Perform Tumor Percutaneous Ablation at Jean Verdier Hospital?

There are 5 basic steps to TPA:

1. Pre-operative CB-CT
2. Placement of the needles/electrodes using US guidance
3. Needle position control using fluoroscopy
4. Treatment
5. Post-operative CB-CT.

There are 3 basic modalities for delivering treatment.

Radiofrequency (RFA)

RFA consists on delivering high frequency current in the deployed electrodes. RFA employs Ionic agitation and results in the coagulation of surrounding tissue providing better destruction of tumor peripheral zone.

Microwave

Microwave energy is delivered to target tissues which causes water molecules in the cells to rotate millions of times per second. The resultant frictional heating over 60 degrees Celsius results in cell death. This technique involves larger ablation zones and faster procedure times

Irreversible Electroporation (IRE)

IRE delivers high-voltage electrical current to pores in the lipid bilayer of cell which causes cell death. IRE uses a non-thermal based method of action and can thus be used to treat tissue near vital structures.

4. Optimization of Patient Radiation Protection

Jean Verdier Hospital focused on 3 primary components for patient radiation protection:

1. Standardization of procedures name
2. Establishment of Local Reference levels
3. Optimization of patient doses

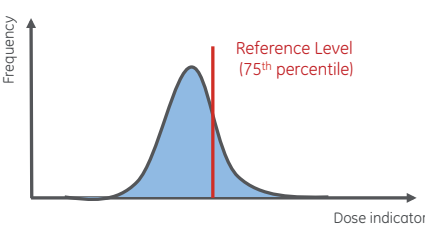
With appropriate mapping of protocol names, the number of named protocols was reduced from 6 to 3.

1. Ablation
2. Ablation RF
3. Ablation Electroporation
4. Radiofrequence
5. Micro-Ondes
6. Micro Ondes

1. Ablation Electroporation
2. Ablation Micro Ondes
3. Ablation RF

Reference Levels (RL)

RL are deduced using statistical analyses, for representative values linked to the delivered dose to the patient: KAP, $K_{a,r}$, fluoroscopy time, number of frames... They are estimated using the 75th percentile method published by the ICRP in the 90s.

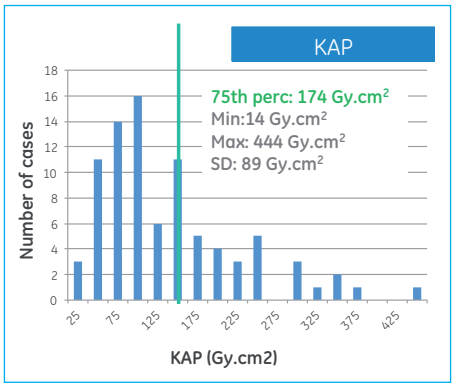


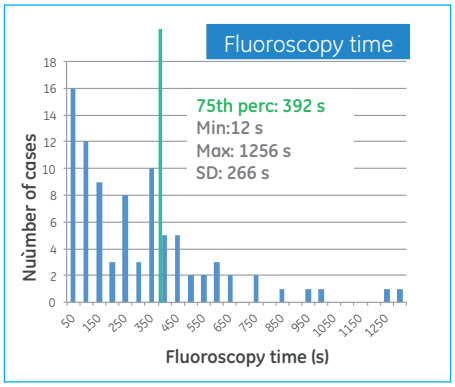
The RL is not a limit of dose. The RL should be considered as an optimization and quality improvement tool.

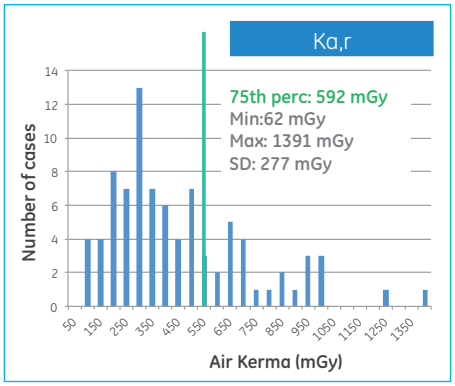
In France there are no published national reference levels for PTA procedures. However, there are recommendations to establish local reference levels.

Results

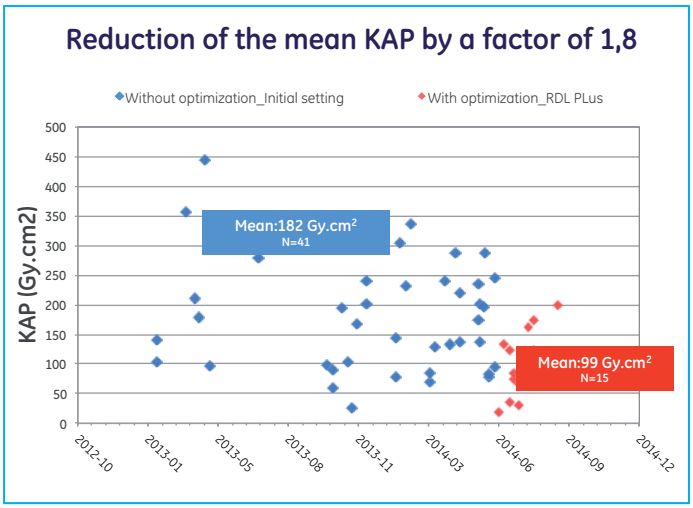
87 exams were monitored between Feb 2013 and Feb 2015. The reference levels for the KAP, Ka,r and fluoroscopy time are 174 Gy.cm^2, 592 mGy and 392 s, respectively. All RL are below the SIR-CIRSE reference values that triggers the patient medical follow up.

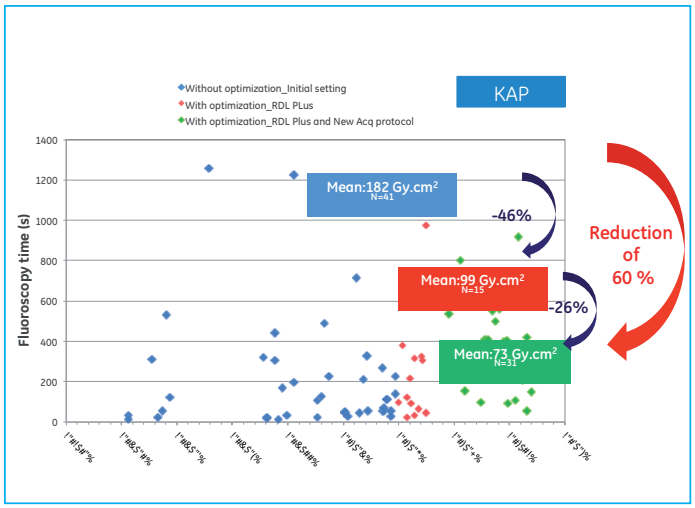


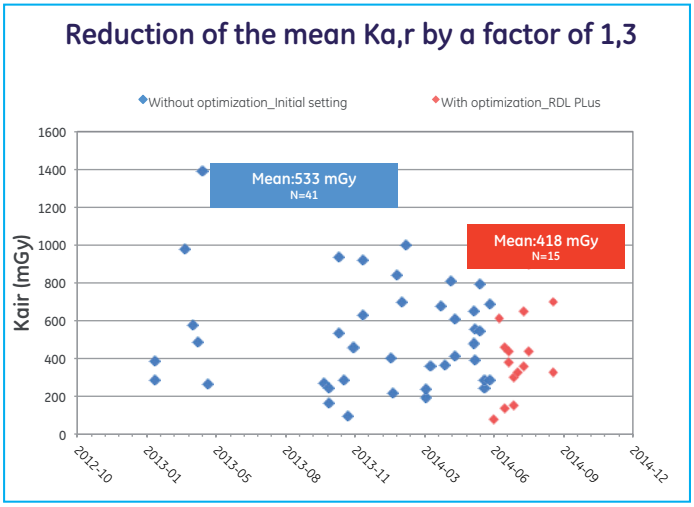


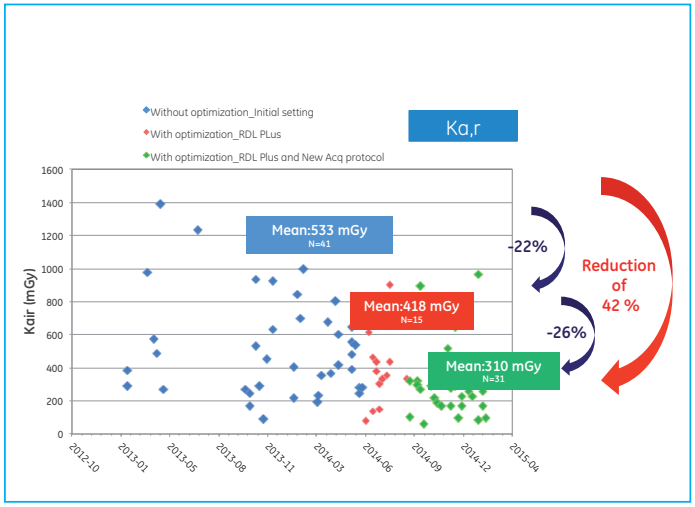


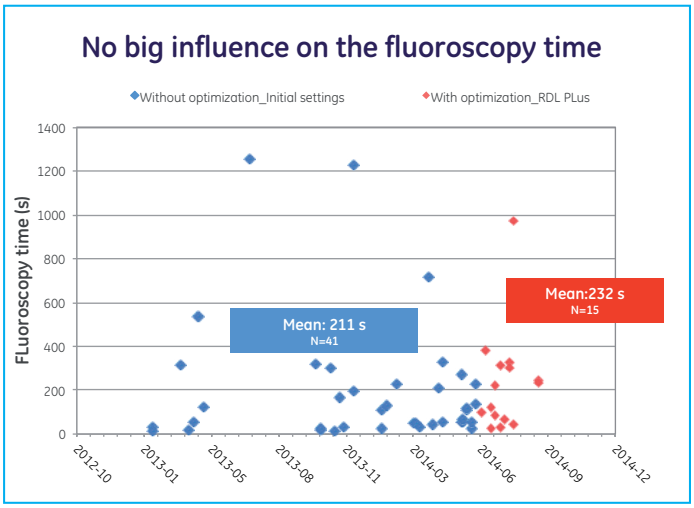
As all percutaneous tumor ablation procedures are performed by the same experimented radiologist, delivered doses were not inter-operator dependent. Consequently, the first step for the optimization of delivered doses to the patients was the modification of the dose settings of the equipment from IQ Standard to RDL Plus. The results of this first action are shown below.

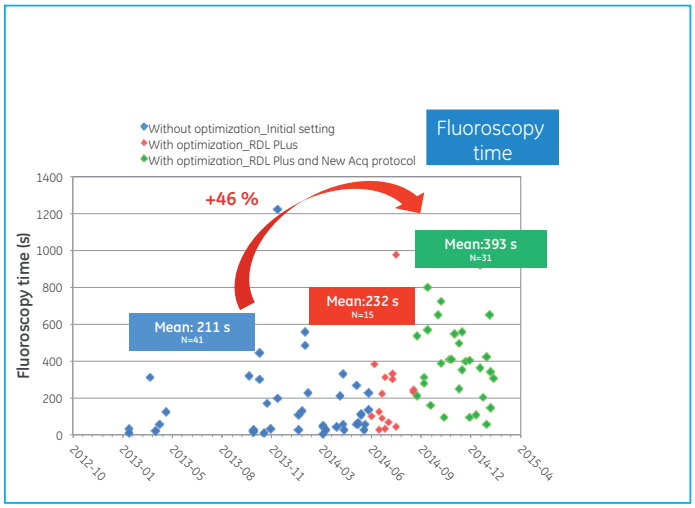












The second step of the optimization process was the modification of the acquisition protocol. Indeed, a new protocol was implemented to treat hypervascular tumors. In this new protocol, rotation speed of CB-CT acquisition was 20°/s while it is 10°/s in the usual protocol. After the acquisition of the CB-CT images, radiology technologists perform the segmentation of the lesion on the 3D images in order to model a virtual lesion which will be exported on the live fluoroscopy images for the radiologist. The results of this second optimization action are shown in the following graphs.

This second optimization action resulted in the reduction of the KAP and the Ka,r of 60 % and 42 % respectively. However, fluoroscopy time increased of 46% over the study period. Fluoroscopy time depends on the number of probes, the number of lesions, the patient BMI and the general complexity of the procedure. However, what mainly explains the increase of the fluoroscopy time is the fact that the radiologist has more confidence in using the new technique in order to implement the probes under X-ray guidance especially when the tumor is not visible enough on the US images.

Conclusion

Using a commercial dose tracking solution (DoseWatch), Jean Verdier Hospital performed the optimization of radiation protection for patients undergoing percutaneous tumor ablation procedures. The optimization process consisted on first, the standardization of procedures names, the establishment of local reference levels and the optimization of delivered doses.

Optimization of the dose settings of the equipment together with the optimization of the acquisition protocol had allowed to reduce the KAP and the Ka,r by 60 % and 42 %, respectively.

Optimization of patient radiation protection is a continuous improvement journey and teamwork is the key driver of a successful strategy.

About GE Healthcare

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