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## **FOLFIRINEC: a randomized phase II trial of mFOLFIRINOX vs platinum-etoposide for metastatic neuroendocrine carcinoma of gastroenteropancreatic or unknown origin**

Julien Hadoux, Pauline Afchain, Thomas Walter, David Tougeron, Vincent Hautefeuille, Carole Monteryuard, Véronique Lorgis, Frédéric Thuillier, Eric Baudin, Jean Yves Scoazec, et al.

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1 **FOLFIRINEC: randomized phase II trial of mFOLFIRINOX vs platinum-etoposide for**  
2 **metastatic neuroendocrine carcinoma of gastroenteropancreatic or unknown origin.**

3

4 Authors:

5 Julien Hadoux<sup>a\*</sup>, Pauline Afchain<sup>b</sup>, Thomas Walter<sup>c</sup>, David Tougeron<sup>d</sup>, Vincent Hautefeuille<sup>e</sup>,  
6 Carole Monteryuard<sup>f</sup>, Véronique Lorgis<sup>g</sup>, Frédéric Thuillier<sup>h</sup>, Eric Baudin<sup>a</sup>, Jean Yves Scoazec<sup>i</sup>,  
7 Côme Lepage,<sup>f,j</sup> and Romain Desgrippes<sup>k</sup>

8

9 Affiliations:

10 a – Endocrine oncology, Imaging department, Gustave Roussy, Villejuif, F-94805 Villejuif

11 b - Department of Oncology, Saint Antoine Hospital, Paris, France

12 c - Department of Oncology, ENETS Centre of Excellence, Hospices Civils de Lyon and Lyon  
13 University, Lyon, France

14 d - Department of Hepato-gastroenterology, Poitiers University Hospital; University of Poitiers,  
15 Poitiers, France

16 e - Department of Hepato-gastroenterology, Amiens University Hospital, Amiens, France

17 f - FFCD EPICAD INSERM LNC-UMR 1231, University of Burgundy and Franche-Comté,  
18 Dijon, France

19 g - Department of Oncology, Cancerology institut of Bourgogne GRReCC, Dijon, France

20 h - Department of Oncology, Limoges University Hospital, Limoges, France

21 i - Pathology, Biopathology department, Gustave Roussy, Villejuif, F-94805 Villejuif

22 j - Department of digestive oncology University hospital Dijon; University of Burgundy and  
23 Franche Comté, Dijon, France

24 k – Hepato-gastroenterology department, Centre Hospitalier de Saint-Malo, F-35403 Saint-  
25 Malo

26

27 \* Corresponding author:

28 Dr Julien Hadoux

29 Gustave Roussy, 114 rue Edouard Vaillant, 94805 Villejuif

30 [Julien.hadoux@gustaveroussy.fr](mailto:Julien.hadoux@gustaveroussy.fr)

31 +33 1 42 11 63 61

32

33 **Keywords**

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35 Gastroenteropancreatic

36 Chemotherapy

37 FOLFIRINOX

38 **ABSTRACT**

39

40 **Background**

41 Poorly differentiated neuroendocrine carcinomas (NEC) are rare diseases with a poor  
42 prognosis. Platinum-etoposide (PE) has been the recommended first-line treatment for  
43 decades. FOLFIRINEC (NCT04325425) is a national multicenter randomized phase II study  
44 which aims to challenge this standard regimen.

45 **Methods**

46 The primary objective is to compare the median progression-free survival (PFS) under  
47 mFOLFIRINOX versus PE. The secondary objectives are to evaluate the objective response  
48 rates (ORR), median overall survival (OS), safety and quality of life. The associated real-time  
49 translational study will establish a molecular profile for each patient enrolled.

50 Main inclusion criteria are: NEC of gastroenteropancreatic (GEP) or unknown origin, metastatic  
51 and RECIST 1.1 evaluable disease, tumor sample available and no contraindication to  
52 chemotherapy. Patients will be randomized 1:1 between PE every 21 days for 6-8 cycles and  
53 mFOLFIRINOX every 14 days for up to 12 cycles and stratified according to center,  
54 performance status, Ki67 and pathological subtype.

55 This trial will randomize 218 patients (24 months of follow-up) to have 80% power to detect an  
56 improvement of the median PFS from 5 months under PE to 7.5 months under mFOLFIRINOX  
57 (HR of 0.67,  $\alpha$  =5%, two-sided). An intermediate analysis is planned at 50% of events.

58 Recruitment started on October 20, 2020.

## 59 1. Rational and aims

60 Poorly differentiated neuroendocrine carcinomas (NEC) of gastroenteropancreatic  
61 (GEP) and unknown origins are rare and heterogeneous diseases. The diagnosis is often done  
62 at the metastatic stage and the prognosis is poor. The standard first-line (L1) treatment is  
63 platinum-etoposide (PE) combination chemotherapy, mostly based on retrospective studies  
64 [1,2]. With this regimen, RR is 40 to 70% but the median PFS is short, between 4 and 9 months  
65 [3,4]. Disease progression almost always occurs during or just after treatment and median  
66 overall survival (OS) is only about 12-15 months for GEP NEC with similar efficacy of either  
67 cisplatin or carboplatin [3,4] and of either oral or intravenous etoposide [5,6]. After progression,  
68 only 40 to 45% of patients will receive a second-line (L2) chemotherapy which will include 5-  
69 fluoro-uracil (5FU) or capecitabine and irinotecan (FOLFIRI [7]) or oxaliplatin (XELOX,  
70 FOLFOX [8]) or dacarbazine/temozolomide [9]. This second-line treatment can provide about  
71 30% of RR and a median PFS of 4 months [4,7,8]. Taken together, these data indicate a major  
72 medical need for improving NEC treatments.

73 Since the first description, thirty years ago, of the PE combination efficacy for what was  
74 called “anaplastic neuroendocrine carcinomas” and referred nowadays to NEC by Moertel and  
75 collaborators, no change has been made to this standard of care [10]. Only one randomized  
76 phase II trial have compared the efficacy of the cisplatin - irinotecan (PI) combination to the  
77 standard PE regimen. This phase II enrolled 66 patients and was terminated prematurely  
78 following interim analysis showing equivalent efficacy. Indeed, the objective RR were similar  
79 in both arm (42.4%), the median PFS was 6.4 months in the PE arm and 5.8 months in the PI  
80 arm, respectively ( $p=0.81$ ), and the median OS was 11.3 months and 10.2 months,  
81 respectively, ( $p=0.37$ ) [11]. A single arm phase II study evaluated PE intensification with the  
82 addition of paclitaxel and found an objective RR of 53%, a median PFS of 7.5 months and a  
83 median OS of 14.5 months which led the authors to conclude to the absence of higher efficacy  
84 as compared to the standard PE regimen [12]. Other studies are almost all retrospective and  
85 have reported equivalent efficacies of either PE or PI, except the Yamaguchi *et al.* study

86 suggesting higher efficacy of PI regimen but this study was not randomized, the studies of first-  
87 line chemotherapy in NEC are summarized in Table 1.

88           Although all studies on second-line treatment of metastatic NEC of GEP or unknown  
89 origin were retrospective, they have suggested that both irinotecan and oxaliplatin, in  
90 combination with 5FU can have anti-tumor effect in NEC [7,8]. In the last decade, the  
91 FOLFIRINOX triplet chemotherapy regimen, combining 5FU, oxaliplatin and irinotecan, has  
92 shown significant efficacy in several digestive cancers such as pancreas [13] or colorectal  
93 adenocarcinoma [14]. Tolerance of this regimen has improved over the years with better  
94 tolerability that has led to the development of the mFOLFIRINOX regimen [15]. mFOLFIRINOX  
95 could be a good L1 treatment in metastatic GEP NEC because: (i) Oxaliplatin, irinotecan and  
96 5FU have anti-tumor effect in metastatic GEP NEC [4,7,8]; (ii) triplet with a potential high RR  
97 could be efficient in these chemosensitive cancers; (iii) the degradation of PS following tumor  
98 progression during/after L1 treatment makes access to a second-line uncertain which argue  
99 for the use of an aggressive L1 treatment; (iiii) administration on a one-day outpatient basis  
100 (day hospital), as well as acceptable adverse events, could have an impact on quality of life in  
101 these patients with a poor prognosis. With the PRODIGE 69-FOLFIRINEC trial hypothesize  
102 that the mFOLFIRINOX triplet may improve the prognosis of patients with metastatic NEC from  
103 GEP or unknown primary.

104           Few data are available on predictive factors of L1 chemotherapy efficacy in metastatic  
105 NEC which are subdivided in 2 main pathological subtypes; eg. small cell NEC (SCNEC) and  
106 large cell NEC (LCNEC). These two subtypes are treated with the same PE regimen, whatever  
107 the primary tumour site, although overall response rate (ORR) seem to differ between SCNEC  
108 (about 50 to 70%) and LCNEC (about 30-50%) in lung and pancreas NEC retrospective series  
109 [16–19]. These data have led to the choice of stratifying the FOLFIRINEC trial according to  
110 pathological subtypes. Few studies have reported molecular profiles of NEC with a perspective  
111 of personalized treatment. Previous studies have mainly focused on *BRAF* mutation in colon  
112 NEC and the efficacy of the dabrafenib-trametinib combination [20–22], contrary to what is  
113 observed in colon adenocarcinoma, which has been suggested to be related to an epigenetic

114 silencing of the epidermal growth factor receptor in colon NEC [21]. Moreover, little is known  
115 on the putative predictive biomarkers to immunotherapy efficacy in NEC of GEP and unknown  
116 origin. Tumour mutational burden (TMB) is between 8.6 and 10.5 mutations/megabase in NEC  
117 of the lung [23,24] but no data exist for GEP and unknown origin NEC. In addition MLH1 and  
118 PMS2 loss of expression by immunohistochemistry mostly due to *MLH1* promoter methylation  
119 (dMMR phenotype) have been reported in 12.4% tumoral samples of a series of 89 GEP NEC  
120 and mixed neuroendocrine neoplasms [25]. In an attempt to expand knowledge on molecular  
121 alterations in NEC of GEP and unknown origin, the FOLFIRINEC-PRODIGE 69 phase II trial  
122 is associated with a “real time” translational study which will establish the tumor molecular  
123 profile of each participating patients for whom tumoral sample is available.

## 124 2. Study design

125 The PRODIGE 69-FOLFIRINEC study is a national, multicentre, prospective, open-  
126 label, randomized and trial comparing the efficacy of mFOLFIRINOX versus PE regimen for  
127 the treatment of patients with metastatic NEC of GEP and unknown origin associated with a  
128 molecular profiling for therapeutic targets and biomarkers identification (Figure 1).

129 Eligible patients will be stratified according to ECOG PS (0 vs 1), Ki67 (<55% vs ≥55%)  
130 and pathological subtype (small cell vs large cell or unknown) and then randomly assigned  
131 (1:1) to either standard regimen arm with platinum (cisplatin 100 mg/m<sup>2</sup> day 1 or carboplatin  
132 AUC 5 day 1, according to physician's choice) and etoposide (100 mg/m<sup>2</sup> intravenous (IV), day  
133 1, 2 and 3) administered every 21 days for 6 to 8 cycles (24 weeks maximum) or experimental  
134 treatment arm with mFOLFIRINOX (oxaliplatin 85 mg/m<sup>2</sup> IV + irinotecan 180 mg/m<sup>2</sup> IV +  
135 LV5FU2 2400 mg/m<sup>2</sup> without 5 FU bolus) administered every 14 days for 12 cycles (24 weeks  
136 maximum).

137 Main inclusion criteria in the PRODIGE 69-FOLFIRINEC trial are patients over 18  
138 years, ECOG PS 0 or 1, with a metastatic NEC or high grade MiNEN with a NEC component  
139 ≥ 30%, of GEP or unknown origin, whatever the pathological subtype (small cell or large cell  
140 or non-small cell or unknown/indetermined) (Table 2). Grade 3 well-differentiated  
141 neuroendocrine tumors according to WHO 2017 classification are not eligible. Patient must not  
142 have received any prior therapy for metastatic disease. Patient with asymptomatic brain  
143 metastases or under stable corticosteroid doses for at least 2 weeks before randomization can  
144 be included; otherwise, radiation therapy prior to inclusion is required in case of symptomatic  
145 brain metastases. Patient must have adequate haematology parameters (neutrophil count ≥  
146  $1.5 \times 10^9/L$ , platelet ≥  $100 \times 10^9/L$  and hemoglobin > 8 g/dL), a creatinine clearance above 30  
147 ml/min (Cockroft & Gault formula) and adequate liver function (total bilirubin ≤ 1.5N, AST/ALT  
148 ≤ 2.5N, or AST/ALT ≤ 5N in case of liver metastases). All patients must undergo  
149 dihydropyrimidine dehydrogenase (DPD) deficiency screening and cannot be included in case  
150 of uracilemia ≥ 16 ng/mL. Other standard exclusion criteria are applied: pregnancy, history of



151 recent malignancy, active HIV or viral hepatitis and any active or suspected acute or chronic  
152 uncontrolled disease that would impair study participation.

153 The radiological assessment will be performed at baseline (within a maximum of 3  
154 weeks before inclusion) using a TAP computed tomography (CT) scan (or magnetic resonance  
155 imaging (MRI) of the abdomen plus chest CT-scan in case of contrast medium allergy), and  
156 the same procedure (CT and/or MRI) will be repeated every 8 weeks until tumor progression  
157 or death. Radiological tumor assessment will be performed according to the RECIST v1.1  
158 criteria. Brain imaging is required at baseline either by CT-scan and/or MRI. Imaging of brain  
159 lesions by CT-scan and/or MRI is required every 8 weeks (+/- 1 week) during treatment and  
160 follow-up if present at baseline.

161

## 162 **2.1. Study endpoints**

163 The primary endpoint is the median PFS. PFS is defined as the time interval between  
164 date of randomization and date of the first radiological progression (according to RECIST 1.1)  
165 or death due to any cause, whichever occurs first, according to the investigator. Patient alive  
166 without progression will be censored at date of last follow-up visit.

167 The secondary endpoints are:

- 168 - centralized PFS by independent reviewed
- 169 - OS which is defined as the time between date of randomization and date of death (whatever  
170 the cause). Patients alive will be censored at date of last news.
- 171 - Best objective RR which is defined as the proportion of patients with an objective response  
172 (complete response (CR) + partial response (PR)) at any evaluation during the treatment,  
173 according to RECIST 1.1 and centralized review.
- 174 - Safety which is defined as the percentage of patients who experienced toxicities and  
175 grading of these toxicities according to NCI-CTC V4. Toxicities will be presented as the  
176 number of patients presenting at least one toxicity by maximum grade.
- 177 - Dose reductions and dose intensity which are defined as the number of treatment cycles,  
178 the dose received and the percentages of actual dose received as compared to the

179 theoretical dose will be described, as well as the percentage of patients with at least one  
180 dose modification/reduction or at least one postponement of chemotherapy.

- 181 - Quality of life assessed by the EORTC QLQ-C30 and EQ-5D-5L questionnaires.
- 182 - Exploratory analyses (see “biomarkers analyses”). The predictive value of each molecular  
183 alterations will be evaluated using correlation with objective RR, PFS and OS, in both arms.

184

## 185 **2.2. Ethical considerations**

186 This study is sponsored by the *Fédération Francophone de Cancérologie Digestive*  
187 (FFCD) and Dijon University hospital. PRODIGE 69-FOLFIRINEC has been authorized by the  
188 French medicines agency (*Agence Nationale de Sécurité du Médicament et des produits de*  
189 *santé*, ANSM) on March 23, 2020. It was submitted and approved (July 20, 2020) by the ethics  
190 committee (*Comité de protection des personnes*, CPP). This trial is registered on the European  
191 Union Clinical Trials Register (EudraCT no. 2019-001013-16) and on the *clinicaltrials.gov*  
192 website (NCT04325425). The study complies with the Declaration of Helsinki and the  
193 principles of Good Clinical Practice guidelines.

194

## 195 **2.3 Statistical methods**

196 For the primary endpoint, the median PFS will be calculated among patients who have  
197 received at least one dose of chemotherapy, whatever the dose and the treatment (modified  
198 intent-to-treat). Median PFS will be given for each treatment arm with their two-sided 95%  
199 confidence interval. The Kaplan-Meier method (Kaplan and Meier, 1958) will be used to  
200 estimate median and curves will be plotted. Log-rank test will be used to compare the 2  
201 treatment arms. Hazard ratios will be calculated using Cox proportional model (Cox, 1984).  
202 Proportionality (Schoenfeld residual methods) and linearity (Martingale residuals) hypotheses  
203 will be checked.

204 The hypothesis of the PRODIGE 69-FOLFIRINEC trial is that mFOLFIRINOX could  
205 increase median PFS from 5 months in the control arm (PE) to 7.5 months in the experimental  
206 arm (H1).

207 With a two-sided risk alpha of 5% and a power of 80%, 203 events (radiographic  
208 progression or death) are required to demonstrate a median PFS difference of 2.5 months  
209 (HR=0.67). With 24 months of follow-up, an inclusion rate of 5 patients/month and a lost-to-  
210 follow-up rate of 5%, 218 patients will be randomized.

211 An intermediate analysis is planned at 50% of events (102 radiographic progression or  
212 death). The intermediate analysis is planned in order to show efficacy at an early stage  
213 (rejection of H0) or futility (accept H0). The p-values will be calculated using the O'Brien-  
214 Fleming function based on the real number of events.

215 As G3 NEC is a rare disease, 48 centers will be open to recruitment throughout France.

216

## 217 **2.4 Biomarker analysis**

218 This study includes a real-time, centralized molecular profiling of the tumor consisting  
219 of immunohistochemistry (IHC) markers (PD-L1 (Programmed death-ligand 1), Rb  
220 (retinoblastoma protein), TP53, MLH1 (MutL Homolog 1)) and a targeted next generation  
221 sequencing (NGS) panel of 161 genes (Oncomine Comprehensive assay V3, ThermoFisher®,  
222 Waltham, Massachusetts, US) associated with the determination of mutational tumor burden  
223 (TMB) and microsatellite instability status (MSI). This molecular profile will be reviewed by a  
224 molecular tumor board and the report will be sent to the investigator, together with the  
225 molecular profile results, within 2 months of tumor sample submission for informing further line  
226 treatment-decision making in the case of targetable alterations.

227

## 228 **Conclusion**

229 PRODIGE 69 - FOLFIRINEC is designed to challenge the standard platinum-etoposide  
230 combination chemotherapy with mFOLFIRINOX for the treatment of patients with NEC of GEP  
231 and unknown origin. The associated translational study aims at identifying biomarkers of  
232 responses in these patients and to draw the mutational landscape of these tumors with the  
233 goal to find targets for personalized medicine. The first patient was included on October 20,  
234 2020, the end of inclusion is scheduled for the end of 2024.

235

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245

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247 None

248

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255

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**Table 1: First-line chemotherapy results in gastroenteropancreatic poorly differentiated neuroendocrine carcinoma**

| Authors                        | n patients | Study design                    | Primary  | Chemotherapy regimen             | response rate (%) | median PFS (months) | median OS (months) |
|--------------------------------|------------|---------------------------------|--|----------------------------------|-------------------|---------------------|--------------------|
| Zhang et al [11]               | 66         | Monocentric randomized phase II | GEP(88%), UK(12%)                                | Etoposide/cisplatin              | 44                | 6.4                 | 11.3               |
|                                | 33         |                                 |  | Irinotecan/cisplatin             | 44                | 5.8                 | 10.2               |
| Hainsworth et al [12]          | 78         | Multicentric monoarm Phase II   | UK(62%), GEP(19%), lung(9%)                      | Etoposide/carboplatin/paclitaxel | 53                | 7.5                 | 14.5               |
| Kulke et al [26]               | 4          | Monocentric phase II            | GEP (84%), UK (11%), lung (5%)                   | Irinotecan/cisplatin             | 25                | 4.5                 | 11.4               |
| Sørbye et al & ali et al [3,6] | 252        | Multicentric retrospective      | GEP (69%), UK (31%)                              | Etoposide/cisplatin              | 31                | 4                   | 12                 |
|                                | 129        |                                 |  | Etoposide/carboplatin            | 30                | 4                   | 11                 |
|                                | 67         |                                 |  |                                  |                   |                     |                    |
| Yamaguchi et al [27]           | 258        | Multicentric retrospective      | GEP (100%)                                       | Irinotecan/cisplatin             | 50                | 5.2                 | 13                 |
|                                | 160        |                                 |  | Etoposide/cisplatin              | 28                | 4                   | 7                  |
|                                | 46         |                                 |  |                                  |                   |                     |                    |
| Walter et al [4]               | 253        | Multicentric retrospective      | GEP (80%) UK (20%)                               | Etoposide/platinum               | 50                | 6.2                 | 11.6               |
| Frizziero et al [5]            | 98         | Bicentric retrospective         | GEP (54%), UK (23%), GU (21%)                    | Etoposide/carboplatin            | 48                | 5.8                 | 11.6               |
| Ramella et al [28]             | 27         | Bicentric retrospective         | GEP(64%), UK(21%)                                | Irinotecan/cisplatin             | 46.4              | 3.7                 | 11.7               |
| Lokesh et al [29]              | 114        | Monocentric retrospective       | GEP (33%), lung(26%), GU (15%), HN (14%), UK(9%) | Etoposide/platinum               | 24                | NR                  | 11                 |
| Yoon et al [30]                | 64         | Monocentric retrospective       | GEP (87,5%), UK(12,5%)                           | Etoposide/cisplatin              | 28                | 3.5                 | NR                 |

|                        |    |                           |  |                                    |      |     |               |
|------------------------|----|---------------------------|--|------------------------------------|------|-----|---------------|
| Bukhari et al [31]     | 58 | Monocentric retrospective | GEP (100%)                             | Etoposide/platinum                 | NR   | NR  | 85% at 1 year |
| Mitry et al [32]       | 41 | Monocentric retrospective | GEP (20), lung (10), HN (4), UK (7)    | Etoposide/cisplatin                | 41.5 | 8.9 | 15            |
| Iwasa et al [33]       | 21 | Monocentric retrospective | Pancreas & biliary (100%)              | Etoposide/cisplatin                | 14   | 1,8 | 5.8           |
| Moertel et al [10]     | 18 | Monocentric retrospective | GEP (14), lung (1), UK (3)             | Etoposide/cisplatin                | 67   | 11  | 19            |
| Deutschbein et al [34] | 18 | Monocentric retrospective | GEP (60%), UK (30%), other (10%)       | Etoposide/cisplatin or carboplatin | 17   | 6.3 | NR            |
| Patta et al [35]       | 8  | Monocentric retrospective | Colo-rectal (100%)                     | Etoposide/cisplatin                | 62.5 | 4.5 | 9.5           |
| Nakano et al [36]      | 30 | Monocentric retrospective | HN (41%), UK (28%), GEP (20%), GU (9%) | Irinotecan/cisplatin               | 46   | 4.5 | 14.3          |
| Lu et al [37]          | 16 | Monocentric retrospective | GEP (94%), UK (6%)                     | Irinotecan/cisplatin               | 57   | 5.5 | 10.6          |
| Okita et al [38]       | 12 | Monocentric retrospective | stomach (100%)                         | Irinotecan/cisplatin               | 75   | 7   | 10.4          |
| Okuma et al [39]       | 12 | Monocentric retrospective | oesophagus (100%)                      | Irinotecan/cisplatin               | 50   | 4   | 12.6          |

Legend: GEP = gastroenteropancreatic, UK = unknown primary, HN = Head and neck primary, GU = Genitourinary primary, PFS = progression-free survival, OS = overall survival, NR = Not reported

**Table 2: Main inclusion and exclusion criteria**

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| <b>Inclusion criteria</b>   |
|---|
| <ul style="list-style-type: none"><li>• Poorly differentiated neuroendocrine carcinoma or high grade MiNEN with a NEC component <math>\geq 30\%</math></li><li>• Small cell or large cell or non-small cell or unknown/undetermined subtype</li><li>• gastro-entero-pancreatic or unknown origin</li><li>• Metastatic disease</li><li>• First-line treatment</li><li>• At least one measurable lesion according to RECIST 1.1 guidelines (CT-scan)</li><li>• Age <math>\geq 18</math> years</li><li>• ECOG Performance Status <math>\leq 1</math> (Appendix 4)</li><li>• Available tumor block</li><li>• Absolute neutrophil count <math>\geq 1.5 \times 10^9/l</math>, platelet <math>\geq 100 \times 10^9/l</math> and hemoglobin <math>&gt; 8</math> g/dl</li><li>• Total bilirubin <math>\leq 1.5N</math>, AST <math>\leq 2.5N</math>, ALT <math>\leq 2.5N</math> or AST and ALT <math>\leq 5N</math> in case of liver metastases.</li></ul>  |
| <b>Exclusion criteria</b>   |
| <ul style="list-style-type: none"><li>• Grade 3 well differentiated neuroendocrine tumor according to WHO 2017 classification</li><li>• Symptomatic brain metastases*.</li><li>• Previously treated by chemotherapy or targeted therapy</li><li>• History or know hypersensitivity to any of the study chemotherapy agents, or their excipients.</li><li>• Known or historical active infection with HIV, or known active viral hepatitis</li><li>• Pre-existing permanent neuropathy (NCI CTC V4.0 grade <math>\geq 2</math>)</li><li>• Known Gilbert's syndrome</li><li>• Pregnant women or breastfeeding mother</li><li>• History of prior malignancy, in the three years before randomization except for cured non-melanoma skin cancer and cured in situ cervical carcinoma</li><li>• Active or suspected acute or chronic uncontrolled disease that would induce excess risk associated with study participation.</li><li>• Patient under guardianship and/or deprived of his/her freedom</li><li>• Partial or complete Dihydropyrimidine Dehydrogenase deficiency (uracilemia <math>\geq 16</math> ng/mL)</li><li>• Severe renal impairment (creatinine clearance less than 30 mL/min, according to Cockcroft and Gault Formula)</li><li>• QTc interval <math>&gt; 450</math> msec for male and <math>&gt; 470</math> msec for female at EKG.</li><li>• <math>K^+</math> <math>&lt;</math> lower limit of normal (LLN), <math>Mg^{2+}</math> <math>&lt;</math> LLN, <math>Ca^{2+}</math> <math>&lt;</math> LLN</li></ul> |

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*\*Patient with asymptomatic brain metastases or under stable corticosteroid doses for at least 2 weeks before randomization can be included.*

**Figure 1: FOLFIRINEC study design**

